Vol. V. — No. 4. April 1923.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

385. (06.112]

NINTH SESSION

ROME : APRIL 1922

GENERAL PROCEEDINGS

2nd Section : LOCOMOTIVES AND ROLLING STOCK

INAUGURAL MEETING

19 April 1922 (morning).

PROVISIONAL PRESIDENT, Mr. A. ALESSANDRI,
ENGINEER,
COUNCILLOR OF THE ITALIAN STATE RAILWAYS,
MEMBER OF THE LOCAL ORGANISING COMMITTEE OF THE NINTH CONGRESS.

The President. (In French.) — I feel assured that the discussions which will take place in this room, and the experiences which you will hear from your colleagues, will be of the greatest interest. I also trust that the results of your debates may be of use to you. It is with this in my mind, or rather to express my confidence in you, that I have undertaken the task of proposing the officers for this section.

In the name of the Permanent Commission, I wish to propose to you as president, Mr. George Gibbs, chief engineer of electric traction of the Long Island Railroad, and reporter on question VIII (Electric Traction), and as vice-presidents : Mr. Paul-Dubois, assistant general manager of the Paris-Orleans Railway Company; Mr. Van Loenen Martinet, engineer in charge of the construction of electric lines for the Dutch Railways, and Mr. A. Floor, head of the Rolling Stock Department of the Danish State Railways.

If there is no other proposition, I declare these gentlemen elected. (*Applause.*)

I also propose, in the name of the Permanent Commission, as principal secretary, Mr. Stalder, assistant engineer to the head of the Mechanical Department of the Federal Posts and Railways of Switzerland. (*Agreed.*)

— The section then completed its Secretariat, and provisionally arranged how its work should be carried out.

Mr. G. Gibbs. — I have to thank the section for the unexpected honour which they have done me in calling on me to preside over its work. I regret that I have not been able to fully prepare myself for my work as President, but I will do my best.

[**621**. 133. (01, **621** .134.3 & **621** .134.4]

QUESTION V

ECONOMIC PRODUCTION AND USE OF STEAM ON LOCOMOTIVES.

Economic production and use of steam; different systems; results obtained :

a) *Superheating the steam; compounding;*

b) *Heating the feed-water;*

c) *Special devices; water-tube boilers, etc.*

Preliminary documents.

1st report (all countries, except those using the English language), by Mr. M. Lacoin. (See English edition of the *Bulletin* of September 1921, p. 1157, or separate issue [with red cover] No. 29.)

2nd report (countries using the English language), by Mr. G. J. Churchward. (See English edition of the *Bulletin* of October 1921, p. 1527, or separate issue [with red cover] No. 36.)

Special reporter : Mr. M. Lacoin. (See English edition of the *Bulletin* of April 1922, p. 653.)

SECTIONAL DISCUSSION

Meeting held on 24 April 1922 (morning).

Mr. G. GIBBS, in the chair.

The President. — I call upon Mr. Lacoin to be good enough to read his summary.

Mr. Lacoin, *special reporter.* (In French.) — I should be glad if members who have any observations to make will kindly do so during the discussion of each section of my summary, which will now be read.

This comprises three distinct questions dealt with under sections *A*, *B* and *C*.

The first section is as follows :

_a_) Superheating is universally adopted in the construction of locomotives for passenger and freight trains. It has not yet been exclusively applied to suburban traffic, but the results given have been satisfactory, especially when the smoke-box dampers, which cuts off superheating when the regular is closed, are removed.

Mr. Van Schouwenburg, Dutch East Indian Railways. — I draw attention to an experiment that has been made by the Dutch East Indian Railways, which had experienced some difficulty in obtaining a degree of satisfactory superheating in trains making frequent stops. In order to do away with these difficulties, we adopted a superheater of small tubes (2 1/2 inches inside diameter and of elements having only two tubes inside the smoke tube). Quite satisfactory superheating was obtained; 752° F. was arrived at and it was even necessary to reduce the extent of the superheating.

Mr. Lacoin. (In French.) — On all French railways and also on a certain number of others, the same difficulties arose, but were got over by doing away with the dampers without experiencing any inconvenience. Thus, on all the French systems, we have found it easier to keep the superheater as it was and simply do away with the damper, because we obtained a satisfactory amount of superheat and have not been troubled with any blocking of the tubes, such as is complained of by the Dutch Indian Railways.

Certain railways have tried superheaters with small elements, others with small tubes, but on account of the difficulty in cleaning the tubes, they have in most cases discarded them.

Mr. Weiss, Swiss Federal Railways. (In French.) — The Federal Railways have dispensed with dampers on their superheaters for a long time without experiencing trouble of any kind.

They also have shunting engines fitted with the new type of Schmidt superheater with small tubes. These engines are also without superheater dampers. In service on the line the steam temperature reaches 770° F., but in shunting operations it is much lower and does not exceed 572° F.

Mr. Bourne, New York Central Railroad. — In the United States as a general practice dampers have been applied to all superheater locomotives with large superheater flues. The dampers are automatic in their operation and cost practically nothing to maintain. On the other hand, where superheaters with small tubes have been applied, dampers were omitted as it was feared there might be difficulty in cleaning the tubes. This trouble did not materialize in service and some very interesting results were obtained as to increased capacity.

Mr. Lacoin. (In French.) — I wish to make a remark with regard to my statement that most of the French railways were not very satisfied with the small tube superheaters. I have since heard that the Paris-Lyons-Mediterranean Railway make somewhat large use of this arrangement, but do not state if they prefer it to others. Mr. Vallantin may perhaps inform us if any difficulties have arisen through their use.

Mr. Vallantin, Paris-Lyons-Mediterranean Railway. (In French.) — On account of the economical results obtained in the working of our new locomotives which had been fitted, when constructed, with superheaters made up of elements fixed in large smoke tubes, we tried also to apply the principle of superheat to all other locomotives which had been built since 1907. There was some hesitation however on account of the expense of scrapping and renewing the firebox and smokebox tube plates which would have been absolutely necessary if superheaters with large tubes were to be fitted. It was while considering this question that our attention was drawn to the so called small tube superheater. This appeared to be just what we wanted and very convenient for us, as all our locomotives were fitted with winged or Serve tubes 2 3/4 inches in diameter. All we had to do therefore was to replace these with smooth tubes of the same internal diameter into which small elements could be fitted.

We began this change on 5 locomotives, the result being perfectly successful, and the trial was extended to a further 10 locomotives of another type, from which we obtained equally good results.

In consequence of these trials we decided to use the small tube superheater generally and fit it to all our piston valve locomotives having Serve tubes 2 3/4 inches in diameter.

The first locomotives changed (six wheel coupled engines with bogie in front, 5 ft. 10 7/8 in. diameter wheels and (33 square feet grate area, which were somewhat « short winded ») gave very satisfactory results, and we have since extended the principle to 80 others.

We have found no difficulty in the upkeep of the tubes nor in cleaning. These engines, which run in link with locomotives of the old type, give an economy, according to the profile of the road, varying from 17 to 24 %.

I should mention, however, that in order to have plenty of superheat we decided that the superheating elements should come very close to the firebox, and the return bends of these elements in the inside of the large tubes were brought to within 11 3/4 inches of the tube plate. On account of this short distance I must admit we had a great deal of trouble, as the tubes burnt away rapidly, we therefore in the last engines increased this distance to 19 3/4 inches, an arrangement which has got over all trouble, and we have had no complaints since.

Sir Henry Fowler, Midland Railway, Great Britain. — The railway company that I represent have never experienced any trouble from the spear points of the superheater elements burning away, although these are placed 1 ft. 2 in. from the firebox tube plate. I attribute our freedom from trouble to the care taken in the manufacture of the elements, and I think that any difficulties which may have arisen in this respect are due to defects of construction.

Mr. Robinson, Great Central Railway, Great Britain. — In introducing superheaters on locomotives on the Great Central Railway I also fitted a small number of engines with dampers. As these however interfered with the steaming and were costly to maintain I eventually removed them and there are now about 500 locomotives on the Great Central Railway fitted with superheaters and we have not experienced any serious trouble in connection with them.

Our general practice is to use large flue tubes 5 1/4 inches diameter with four superheater pipes inside, but in some cases we have used 3 inch tubes with two superheater pipes with the object of ascertaining what increased life we can obtain from the firebox tube plates. These small flue tubes have the effect of stiffening the firebox tube plate and the experiment has proved satisfactory.

The maintenance of the superheater element ends has caused trouble especially when oil fired, but this has been overcome by dispensing with oxy-acetylene welded ends and substituting a solid wrought steel forged end.

Mr. Bourne. — Different working conditions under which locomotives operate permit of different operating methods. Without question locomotives are operated at longer cut-offs in the United States than is the general practice in Europe and with their large grate areas and heavy fires are frequently operated on descending grades, or shut off for brief periods, with deep incandescent fires, and dampers or their equivalent are certainly necessary to protect the superheater units or elements. On some of the Eastern railroads where anthracite coal is burned, the locomotives pass over the summits of long grades with heavy incandescent fires and run distances as great as thirty miles without working steam or having fresh coal supplied to the firebox. Some roads have removed the dampers, but periods of operation without them have shown conclusively that they are necessary and they have been re-applied.

Mr. Kejr, Czecho-Slovakia State Railway. (In French.) — Since 1913, there has been a considerable increase in the number of superheated locomotives in our country. It is sufficient to point out that more than half of the locomotives of classes 310, 910, 429, 629, 270, 80, 365 and 423, which were built for our lines after 1913 are all fitted with superheaters. The good results obtained from locomotives with simple expansion and superheat naturally brought about the actual scrapping of engines fitted with several cylinders, and we now possess, on our Western lines, one type only of modern locomotive fitted with four cylinders, compound and superheated class 310. This type, which has proved very powerful, requires however frequent and costly repairs, and for this reason our latest type 365.0 — of superheated locomotives for express trains, the drawing of which I have handed to the secretary of this section, — has been constructed with simple expansion. It is rather interesting to compare the locomotive of type 310 with that of type 365.0.

Type	*310.*	*365.0.*
Grate area, in square feet.	49.73	43.06
Total heating surface, including superheater, in square feet	2 156.10	2 928.97
Steam pressure, in lb. per square inch	213.34	184.90
Steam cylinders (diam.), in inches.	2 × 15 3/8 2 × 26	2×22 7/16
Strocke, in inches	28 3/8	26 3/4
Adhesive weight, in English tons.	43.3	45.0
Total weight, in English tons	84.6	72.7
Maximum speed per hour, in miles	62.1	55.9

The difference in price should also be taken into account. At the present time locomotives of 310 class would be much more expensive than those of 365.0 class. To compare their working capabilities, locomotive 365.0 takes the place of class 310 for express work on the line from Prague to Budějovice. This line has many curves and many long gradients of 10 $^{00}/_{00}$. At the same time, engine class 365.0 pulls express tains of 400 t. without assistance, whilst engine class 310 requires a pilot engine when the load is above 350 t. under the same conditions. Moreover, engine 365.0 consumes less water and coal than 310, and the lubricants required for the latter are much more than for 365.0. We are hoping too that the maintenance of class 365.0 will be less costly than 310. Finally, we may add that the acceleration at starting is much more rapid than with locomotive 310.

As regards local lines, we are trying for the first time the Schmidt superheater with small diameter tubes which we have had fitted to a certain number of new tank engines class 423.0 (locomotive with simple expansion and four coupled axles with one carrying axle in front and one behind). It is thought that superheat will increase their power and decrease the fuel consumption. Locomotive 423.0 is required to pull heavy trains over local lines, and I have handed the drawing of this locomotive to the secretary of the section.

I also wish to mention that the tenders of locomotives class 365.0 are fitted as well as a large number of locomotives of other classes with a Halla-Haken fuel conveyor system made by two Czecho-Slovakian engineers, Mr. François Halla, divisional superintendent at the Ministry of Railways at Prague, and Mr. Aleyse Haken, engineer at the Breitfeld Works, Daněk & Co. at Prague (1). It may be said that the results obtained with the help of this arrangement are most satisfactory.

Mr. de Vargas, Northern Railway of Spain. (In French.) — As long as we used copper fireboxes on the Spanish railways, we found no difference, but as soon as we bought American engines fitted with steel fireboxes we had some trouble.

I think it advisable to use copper fireboxes only and that they will become general, and as far as we are concerned, we find that they are more efficient.

The fault with steel fireboxes is that the tubes are liable to leak, a trouble which is not so prevalent with copper fireboxes.

The President. — If no one else desires to speak on the first point, the discussion is closed.

We reach the discussion of the second point : Superheating applied to old saturated steam locomotives.

Mr. Bourne has the floor.

Mr. Bourne. — In the United States there are approximately 42 000 superheater locomotives, and as to the remaining approximately 20 000 saturated locomotives, 50 % may be considered too old or too near retirement to justify the cost of fitting superheaters.

Mr. Lacoin. (In French.) — I should like to say a word on the subject of the summary proposed in my report. It was worded as follows :

The application of superheat to saturated steam engines may be advantageously done when these are in the shops for repairs, especially to powerful engines of recent types.

After conversation I have had with several delegates, I think we might accentuate this summary and better reflect the opinion of the majority of the members by changing the sentence « might frequently be an advantage » to « is frequently an advantage ».

The chief difficulty is a question of weight, and consequently with old type locomotives, the axles of which are already loaded to the maximum allowed, superheating cannot be applied easily.

---

(1) A description of this conveyor is given in the appendix 2.

Mr. Weiss. (In French.) — The Federal railways applied superheating to new locomotives for the first time in 1905. In 1910 they commenced fitting superheaters to old engines with two cylinders type 1C. It was not considered possible to keep the cylinders with flat valves, so these were replaced with poppet valves (Lentz system). A trial was made in 1913 of changing a four cylinder compound locomotive type 2C into a superheater (Schmidt's with 21 elements) without changing the cylinders which were fitted with flat balanced valves. Only the system of lubrification was altered, and this by introducing the oil under the valve by means of a mechanical lubricator. This arrangement has given us every satisfaction, and up till now we have altered about 30 locomotives of the same type (2C) into superheaters. In the last locomotives the superheater was enlarged to 24 elements, and its maximum temperature varies from 662 to 680° F.

After obtaining this satisfactory result with superheating in conjunction with flat valves in locomotives type 2C (four cylinder compound) other engines were altered, and first of all those of simple expansion (type 1C). No more cylinders were changed and the balanced flat valves which they already possessed gave the same good results. The superheat temperature rose to about 644° F.

Another class of engines, type 1D, four cylinder compound was already fitted with piston valves. It was therefore possible to change them into superheaters without much difficulty.

Up to date about 100 locomotives have been altered, one being a two cylinder compound. One locomotive working on the metre (3 ft. 3 3/8 in.) gauge railway, which is fitted with balanced flat valves, has a Schmidt superheater with small tubes. One of its valves is cast iron, and the other brass. The latter gives better results than the cast iron one. The maximum temperature is 680° F., and the general efficiency of this locomotive is exceedingly good.

Our administration, however, was not the first to try superheating with flat valves, for if I am correctly informed, this was done by the Lancashire & Yorkshire Railway in England. I do not know whether this company has continued to alter its locomotives in this way.

Mr. Robinson. — In the experiments we have made we have found no difficulty in using ordinary slide valves, unbalanced, with superheated steam, and I think it is of interest to point out this fact to the section.

Mr. Van Schouwenburg. — The interesting question is not a matter of knowing if it is possible to make these alterations or not, but to ascertain if the cost of the alterations to the boiler and cylinders would be profitable. The Dutch East Indian Railways on this subject would like to obtain the opinion of companies having made more experiments than it has.

Mr. Weiss. (In French.) — We have only engines of recent construction. Old locomotives did not warrant this expense. A superheater is put in if it is necessary to change the firebox or the tube plate, for in that case there is only the smokebox tube plate to renew in order to fix the superheater.

We have tried to fix a time in which the fuel economy would compensate for the cost of the alteration, and found that it took from one and a half to two years to pay for the change by means of the economy made in coal. An economy of 10 % to 12 % is realised with four cylinder engines in comparison with locomotives that have not been altered. The metre gauge engine with small tubes shows an economy of 25 % in its ordinary running service.

These figures show that on our railways the alteration from saturated to superheated steam is the proper thing to do.

Mr. Bourne. — On the New York Central Lines approximately 2 300, or practically all of the more modern saturated locomotives have been converted to superheaters. Some difficulties have been experienced where slide valve locomotives have been equipped with superheaters as due to design of the valve, it has a tendency to warp or distort at the high steam chest temperature of superheated steam, and there is difficulty in maintaining a uniform contact between the valve and the seat. In some cases new piston valve steam chests have been applied by carefully fitting and bolting to the slide valve cylinders.

It has not been our practice to change cylinders on piston valve locomotives when converting, except in cases where increased tractive effort has been desired and frames and running gear permitted of the increased stresses. There are many classes of locomotives where it has been preferred to take the benefit of superheating in increased sustained boiler capacity. For instance : The superheating of certain classes of locomotives hauling some of the heavy, fast passenger trains between New York and Chicago was sufficient to avoid the practice of double-heading or the use of a second leading locomotive, and the schedule could be made with as many as four additional cars, — the sustained draw bar capacity of the locomotive being increased as much as 35 %. Dynamometer car tests of a *Consolidation* locomotive on the Big Four Division of the New York Central Lines in 1915 showed over 40 % increased draw bar horse-power without any other changes but the application of superheater.

Mr. Drouin, Beira-Alta Railway, Portugal. (In **French**.) — From the point of view of small railways who have alterations to make to their locomotives and have to do so at the least possible expense, it would be interesting if the question of the possibility of making use of flat valves could be definitely cleared up, especially as there seems to be contradictory views on the subject.

Mr. Lacoin. (In French.) — The French Est Railways have tried applying superheating to engines with flat valves and have been quite satisfied with the result. The Swiss railways therefore are not alone as regards this, and the problem seems capable of easy solution.

Mr. Stalder, *principal secretary.* (In French.) — I know of a case on the Swiss railways in which good results were obtained with the small tube superheater which gave a superheat of 788° F. The locomotives were superheated without alteration to cylinders or pistons. The flat valves were purposely retained, but they were balanced and lubricated through holes drilled in the port faces. The oil is supplied by means of mechanical lubricators.

Mr. Robinson. — On the Great Central Railway slide valves working with superheated steam and in many cases unbalanced have been employed under very advantageous conditions, and I attribute their success to be partially due to the employment of forced lubrication from a specially designed lubricator on the intensifier principle.

Of course all new engines are designed with piston valves and engines requiring new cylinders are similarly fitted.

Meeting held on 24 April 1922 (afternoon).

Mr. G. GIBBS, IN THE CHAIR.

The President. — We have this morning discussed paragraphs *a* and *b* of No. 4 of Mr. Lacoin's report.

We pass on to paragraph *c*.

The conclusion is thus formulated :

In consequence of the use of superheat there is a tendency for two cylinder locomotives with simple expansion to take the place of four cylinder compounds, even for very powerful engines. The arrangement with four cylinders non-compound has been abandoned.

Mr. Lacoin has the floor.

Mr. Lacoin, *special reporter.* (In French.) — It appears that simultaneous superheating and compounding on engines of small power is now absolutely abandoned, that is to say, on engines with less than 32 1/4 square feet grate area, or thereabouts. Where opinions appear to differ, it is as a rule with respect to the more powerful engines. This is no doubt due to the fact that with engines of smaller power the existance of four cylinders causes interior friction, which minimises the advantage obtained from compounding. I think therefore if compounding and superheating were combined on engines of great power, very interesting results would be obtained.

Mr. Bourne. — On the New York Central Lines compound locomotives have been progressively put out of service by converting to simple and applying superheaters as the locomotives pass through the shop for heavy repairs. As a general statement the only compound locomotives now in service or being built in America today are those of the Mallet or articulated design.

Mr. Vallantin. (In French.) — We do not consider on the Paris-Lyons-Mediterranean Railway that the abolition of compounding is a question that is definitely settled. After the war the rolling stock was generally much run down, and this had an influence tending to abolish compounding.

The difficulties which had to be faced in order to put the stock in good condition were great, and as they would have been much less if there had only been simple expansion engines to deal with, it was thought that this type was preferable and that they would repay by lesser upkeep costs, the supplementary expenses which would result from abandoning compounding.

The French railways generally have stuck to their compound engines. The Midi Company has put into service *Pacific* engines with simple expansion. The Paris-Lyons-Mediterranean Railway has up to now remained faithful to its compound engines and has not yet ordered a *Pacific* with simple expansion. To my knowledge, up to the present, no proper systematic trials have been made between engines of the same power with the object of determining experimentally if one type is really more economical than the other. In any case the French railways are going to make this trial, and the various railways have come to an understanding with respect to it. The Paris-Lyons-Mediterranean has asked the Midi and the Paris-Orleans to each lend it five locomotives of the *Pacific* type in exchange for five of their locomotives. The engines will be put into regular service, and at the end of three or four months after they have been running under exactly the same conditions on the three railways, it will be possible to form a more certain opinion as to their comparative value. Up to the present, however, I do not think it can be definitely stated that a simple engine is as advantageous as a compound engine of the same type.

Sir Henry Fowler. — The Midland Railway Company have found three cylinder compound locomotives, fitted with superheaters, very satisfactory. The results given by this type for coal consumption per ton mile are better than any we have seen published for any railway.

Mr. Robinson. — The arrangement of four cylinders, non-compound, is now largely used on the Great Central Railway both for express passenger and fast express goods trains, and has proved satisfactory.

Mr. Bréville, French Nord Railway. (In French.) — Speaking for the French Nord, I associate myself with the appreciation expressed by Mr. Vallantin with regard to four cylinder compounds with superheat. I have just ordered a number of very powerful locomotives in which I have kept to compounding with superheating. So far we have found no upkeep difficulties. We have at work a large number of compound engines and have never noticed any inconvenience in fast running. In addition we have had the same experience as Mr. Robinson, namely, that the addition of superheat has resulted in an extra economy.

For all these reasons we remain strongly in favour of the compound locomotive with superheat, especially for hauling fast trains.

Mr. Drouin. (In French.) — Could you give us the percentage of improvement?

Mr. Bréville. (In French.) — It is about 10 %.

M. Labarre, French Est Railway. (In French.) — We had on the Est Railway a series of six wheel coupled 5 ft. 9 in. engines with four cylinders which at first were not fitted with superheaters. Later on these were added, on account of the economy and advantages that resulted. Our opinion therefore coincides with that of the Paris-Lyons-Mediterranean and the Nord Railways.

Mr. Weiss. (In French.) — The Swiss Federal Railways ordered, in 1912, five compound locomotives type 1E : two with four equal cylinders and three with four compound cylinders. The comparison between these two types showed that the compound engine was much superior to the simple expansion engine. The economy resulting from the compound engine worked out to about 20 %. This determined us on altering our engines with four equal cylinders into compounds.

Our administration is exceedingly partial to the compound system with superheat, as it is of great importance that the engines should be as economical as possible.

As regards maintenance, we have experienced no special difficulties.

There is one point of special importance that should be mentioned, this is the variation of the weight through the wheels on to the rails whilst running. Formerly it was said with truth, that the compound engine was the best, because in running the pressure of the wheels on the rails was nearly constant. We have made a calculation with regard to this and find that there is only a variation of pressure on the rails of 7 1/2 t. (static load) to 8 1/2 t. with four cylinder engines driving on to two axles, whilst for two cylinder simple engines of a somewhat similar type the load varies from 7 1/2 t. (static) to 10 or 11 t.

Mr. Gresley, Great Northern Railway, Great Britain. — I should like to say a few words on the question of conversions of locomotives to superheaters. In the case of existing compound locomotives there is little advantage or economy in fitting them with superheaters. Such economies as may result will not repay the cost of conversion. There is a tendency in England and on the Continent, particularly in Germany, to extend the use of three-cylinder single expansion engines fitted with superheaters. It is found in England that three-cylinder engines start easier than two-cylinder even when the cut off of steam in the cylinders in full gear is as early as 60 % of the stroke. The steam is therefore used more economically in three-cylinder than in two-cylinder engines as the latter have to have a later cut off to prevent difficulties in starting.

Mr. Lacoin. (In French.) — My colleagues of the Nord and Paris-Lyons-Mediterranean have given the opinions of those French railways which are favourable to applying superheating to compound locomotives. As regards this, I should like to remark that two very different questions may be asked. The first is whether there is a real advantage in superheating compound locomotives. I presume there is no doubt about that.

There is, however, another question, which is, whether in engines of known power an equal or greater economy is obtained from simple expansion engines with superheat compared with compound locomotives and superheat. With regard to this, I would point out that on the Orleans Railway we have compared the working of a considerable number of *Pacific* locomotives (we have 100 compound *Pacific* superheated engines and 50 with simple expansion) which are in service. We found that the superheated simple expansion engines consumed 5 % less than the others. We do not pretend from this that non-compound two cylinder locomotives are always more economical, but that in any case we have obtained in the ordinary running service this economy of 5 % which has enabled us to reduce the fuel bonus allowed to our drivers.

If then the question of simple expansion engines compared with compounds should be discussed, it seems to be proved that practically similar results may be obtained with both arrangements.

Mr. Bourne. — It would be a mistake to consider this question wholly from the point of coal economy, and in arriving at any conclusion, careful consideration must be given to the cost of maintaining the compound locomotive. In America it has not been found advantageous to continue the compound system on account of the excessive maintenance costs. These heavy maintenance charges may not be in evidence when the compound locomotive is new, but after it has been in service for some time and has passed through the shop for one on two heavy repairs, they are a very vivid reality for the locomotive department. It is a fair statement to say that the compound locomotive has proved too costly from a maintenance standpoint for American roads to operate. Two cylinder, simple locomotives have proved to be quite as economical as the compound locomotive and very much cheaper to maintain.

Mr. Rennes, Andalusian Railways. (In French.) — Independently of the application of compounding and superheating, it is possible to obtain reductions in fuel consumption and an improvement in the output over old locomotives by modifications in the design of boilers (see my article in the *Revue générale des chemins de fer* for January 1922).

Mr. Brévillé. (In French.) — I consider that an investigation into the fuel question is most interesting, because we are coming to the point of using in unit time a quantity of fuel which appears to me to be the maximum a fireman can deal with, even if he is a strong man. Consequently each time we are able to produce an economy in coal, it is not only the financial side of the question which is of interest, but also the possibility of effectively increasing the power of the locomotive, which is only theoretic if the fireman cannot deal with the fuel required. This fireman could handle a given quantity of coal in an hour, but it depends on him whether he can increase this by 3 to 4 %. If therefore a fuel economy of 10 % is obtained, it gives an opportunity of having heavier and faster trains worked with one fireman, which has decided us to keep to the type of four cylinder compound with superheat.

Mr. Lacoin. (In French.) — I think that the wording as given in my summary sums up exactly. There are still a certain number of lines which use four cylinder compound locomotives, but this number is slowly but surely diminishing Only half of the lines in France now build them, and this tendency is constantly growing, especially for goods trains.

Mr. Brévillé. (In French.) - It seems to me that the wording in the summary is much too absolute. If we agree to a resolution stating that two cylinder engines with simple expansion and superheat have a tendency to take the place of four cylinder compound locomotives, we should make a statement which is not admitted by everybody. It seems in fact to result from the discussion that in England it is considered better to replace compound locomotives with those of simple expansion, and I seem to have heard that on certain lines the three cylinder locomotive with superheat would become the standard type. I ask therefore that the first part of the statement should be somewhat altered, and propose that it should take this form : « Thanks to the use of superheat, two cylinder locomotives with simple expansion may be used in the same service as even very powerful locomotives and concurrently with four cylinder compound locomotives. »

This way of putting it would conform better with the existing situation in various countries, notably Switzerland, England and France.

Mr. Lacoin. (In French.) — We might cover all opinions by changing the last sentence as follows :

« Thanks to the use of superheat, two cylinder locomotives with simple expansion tend to take the place of four cylinder locomotives, even those of great power. In the case of greater powers, the preferences of the companies are divided between the two arrangements. »

Mr. Bréville. (In French.) — That will not satisfy me. Would it not be possible to say : « Thanks to the use of superheat the preference of the various companies is divided between two cylinder locomotives with simple expansion and compound locomotives fitted with superheat? » In that way we should be better able to resume the discussion. To sum up, the companies show very diverse preferences, but we cannot talk of substitution. This exists on certain lines, but on others we shall see that the compounds will one day take the place of two cylinder engines. A short time ago, compounding seemed to be a necessity over a great part of the continent.

Mr. Lacoin. (In French.) — I accept this amendment as regards engines of great power. With regard to engines of average power, I think I am right in saying that compounding with four cylinders has practically been abandoned.

Mr. Bréville. (In French.) — Do you think that in these times many more engines of small power will be built? It is not my impression at least.

The President. — It is always difficult, for a numerous committee, to draw up a text. I propose therefore that Mr. Lacoin and Mr. Bréville decide after the meeting on the text that they will propose to the section. (*Agreed to.*)

Mr. Gresley. — It should be said that in England the tendency is towards the adoption of single expansion locomotives having three or four equal cylinders.

Sir Henry Fowler. — Some very interesting experiments have been made with three cylinders compound locomotive.

The President. — The discussion is therefore closed for the moment and we pass on to paragraph *d* :

The fuel economy obtained by the application of superheat may be estimated on the average, in ordinary working conditions, to be about 10 to 15 %. This economy however is very variable, according to the work done and the condition in which the parts are kept, and it is necessary to be more particular in this upkeep than with saturated steam engines.

Mr. Bréville. (In French.) — The true meaning of economy should be defined. What is one comparing with? Not with a compound engine, but is it a comparison with a two cylinder simple expansion engine with saturated steam? It is necessary to state definitely with what the comparison is made. As drawn up, the wording of the summary may lead to confusion. It might be thought that the economy realised referred to any kind of engine.

Mr. Lacoin. (In French.) — The percentages given correspond with averages and in fact the economies shown are not substantially different according as the comparisons were made in regard to compound or non-compound locomotives.

The President. — Do you insist on the text being modified, Mr. Bréville?

Mr. Bréville. (In French.) — No, Mr. President.

Mr. Robinson. — On my system the diminution in the fuel consumption varies from 10 to 20 % for passenger locomotives. An average of 10 to 15 % economy is obtained taking passenger and goods engines together.

Mr. Drouin. (In French.) — Would it not be worth while to find out and record the real economy obtained by the application of superheat, either to simple expansion engines, or to compound engines?

The comparisons that have been given vary from 5 to 20 %.

Mr. Weiss. (In French.) — This is a very difficult question to answer.

The Swiss Federal Railways have identical engines, four cylinder compound working with saturated steam and with superheated steam. We have engines that have been changed into superheaters and engines that have not been altered at our various depots. Both types are doing indentical work, and we find a variation of economy in fuel consumption from 5 to 14 % per 100 tkm. in favour of the superheated locomotives. If the engine is not sufficiently loaded, there is not much superheat and consequently the economy is not great. This is an additional reason for keeping to compounding. Even on those trains which are not very heavy, there is still an advantage in compounding.

As regards class 1D engines, the average economy of the superheater locomotive varies from 10 to 12.4 %. One is referring in all cases to four cylinder compound saturated locomotives and four cylinder engines with superheat.

On a narrow gauge railway we have a superheater engine running that can be compared with similar simple expansion engines, and found the economy obtained from the superheated engine to be 25 %. It should be pointed out, however, that this superheater is one with small tubes which I referred to this morning.

Mr. Lacoin. (In French.) — The President has asked if I had any objection to altering the wording in my conclusion as follows :

« The fuel ecomony obtained by the application of superheat to engines of simple expansion may be estimated at 15 to 20 %. »

I have no objection to an alteration, but in this case I should propose to adopt the figures 10 to 20 %. My figures were arrived at by classifying the whole of the details which were given to me. These details were very variable as they ranged from 0 to 25 %. I propose therefore that we accept the figures of 10 to 20 % as regards engines running with saturated steam.

The President. — As for the preceding paragraph, I shall beg Mr. Lacoin to come to an agreement with his colleagues to present to us a resolution later on. (*Assent.*)

Paragraph *e* :

The special arrangements adopted originally for the valves and pistons of superheat engines have a tendency to become more uniform and simpler and more like those used on saturated steam locomotives. Piston valves are exclusively used for the high pressure cylinders and packings with sliding joints and outside cooling for the rods acted on by live steam. The area of the cylinder relief valves has also been increased. There are the only special arrangements, the necessity for which has been universallly recognised.

The same tendency towards simplifications is apparent in the instructions given to the drivers.

— This resolution is adopted without discussion.

Paragraph *f* :

Some administrations use at the same time both inlet air valves and by-pass, the necessity for both of these does not appear to be yet completely established.

Mr. Van Schouwenburg. — I have had

the opportunity of experimenting with two types of locomotives with inlet air valves and short circuits. With the aim of simplifying the working of locomotives, trials have been made in suppressing the short circuiting device. These experiments brought about breakages, so that I have been obliged to put back the short circuit device in service. I should be pleased to know the results of the experiments that other delegates have made in the same matter. Is it possible, according to them, to make the inlet air valves work without the short circuit device?

Mr. Weiss. (In French.) — The Federal Railways have tried several arrangements.

We have also tried air relief valves on the high and low pressure steam chests, and bye-pass on the two groups of cylinders. This is rather a complicated combination. We made these trials in order to find out what should be done as regards future orders, and we concluded that the best system to adopt was air relief valves for the high pressure cylinders and bye-pass for the low pressure cylinders. In this way we obtain as little resistance when running with closed regulator, as would be the case by bye-passing the two groups of cylinders. The bye-passing arrangement for high pressure cylinders had a mechanism which was too complicated, especially as regards upkeep, and this is why we have discarded it and apply the bye-pass in the form of an automatic valve to the low pressure cylinders only. For simple expansion engines we only use the bye-pass valve and no air relief valve. This valve is extremely simple and is shown in Mr. Lacoin's report figure 22. With regard to it, I should point out a little mistake; the diameter of the hole for the admission of steam should be 10 mm. (3/8 inch) instead of 16 mm. (5/8 inch) as shown. If the diameter is made too big the action of the valve is too abrupt and it breaks, but if the hole is only 10 mm. (3/8 inch) the valve works well.

Mr. Gresley. — I agree with the text of the conclusions, but I wish to emphasise that the tendency on the Great Northern Railway is to adopt the simplest device. Any difficulties which have arisen in the employment of snifting valves is due to faulty design or construction. Properly designed snifting valves give no trouble at all even after many years use. They can be fitted to the header and there is no necessity to adopt any by-passing arrangement. More than 500 superheated locomotives fitted with suitable snifting valves are running on the Great Northern Railway.

Mr. Robinson. — The Great Central Railway has abandoned bye-pass valves on the cylinders and adopted a steam circulating device in conjunction with the blower valve together with a header relief valve operated by the regulator. Snifting valves, as mentioned by Mr. Gresley, are also employed and the experiments we have carried out are very favourable.

The President. — I find in reality the text of the conclusions meets with no opposition. I therefore declare it to be adopted.

Paragraph *g* :

Corliss and similar type valves and the unaflow arrangement have made no progress as far as locomotives are concerned.

— Adopted.

The President. — Mr. Lacoin has come to an agreement with his French colleagues to present a new text for paragraph *a*. I shall now ask him to speak.

Mr. Lacoin. (In French.) — I beg to propose the following resolution which I think will satisfy everybody after the discussion which took place just now :

« SECTION *A* : SUPERHEATER STEAM.

« *a*) Superheating is universally adopted in the construction of locomotives for passenger and freight trains. It has not yet been exclusively applied to suburban traffic, but the results given in these services have been satisfactory, especially when the smokebox dampers, which cut off superheating when the regulator is closed, are removed;

« *b*) The conversion of saturated to superheated steam engines may frequently be advantageously carried out when these are in the shops for repairs, especially with powerful engines of recent types;

« *c*) Owing to the superheat, the use of two cylinder single expansion and superheater locomotives has increased. For powerful engines the preferences of the railways are divided between two cylinder single expansion, the four cylinder compound and the three or four cylinder single expansion all with superheaters;

« *d*) The fuel economy obtained by the application of superheat to the single expansion engines may be estimated on the average to be for ordinary working conditions about 10 to 20 %. This economy however varies considerably, according to the work done and the condition in which the parts are kept, and it is necessary to pay more attention to upkeep than with saturated steam engines;

« *e*) The special arrangements adopted originally for the valves and pistons of superheat engines have a tendency to become more uniform, simpler and more like those used on saturated steam locomotives. On new locomotives piston valves are exclusively used for the high pressure cylinder and packings with sliding joints and outside air cooling for rods acted on by live steam. The area of the cylinder relief valves has also been increased. These are the only special arrangements, the necessity for which has been universally recognised.

« The same tendency towards simplification is apparent in the instructions given to the drivers;

« *f*) Some administrations use both air relief valves and bye-passes. The necessity for both of these does not appear to be yet completely established;

« *g*) Corliss and similar type valves and the uniflow arrangement have made no progress. »

— **This text was adopted.**

SECTION *B*.

Mr. Lacoin. (In French.) — I would like to point out, that as a result of the contents of the other reports, I had already modified my first summary in my special report, as later information showed me that the position in which the subject in question stood had changed somewhat. My modified summary was reproduced in the number of the *Bulletin of the Congress*, which gives the summary of the special reports, but after conversation with several of my colleagues, I was induced to still further modify this summary, and finally this is the text I propose for discussion :

« Certain railways have already made extensive trials, and the time seems to have arrived when feed water heaters may be put into general use. The trials however undertaken by the various companies do not yet seem to permit a sufficiently accurate comparison to be made to enable any definite conclusion to be arrived at as regards the superiority of any one type. It would be worth while to arrive at a definite conclusion as soon as possible with a view of encouraging the general use of this class of apparatus. »

Sir Henry Fowler. — I do not agree with these conclusions in this sence, that I do not consider that it can be definitely stated as yet that there is net saving in adopting feed water heaters when the first cost and maintenance is taken into account.

Mr. Gresley. — I concur with Sir Henry Fowler. I am not satisfied that even the theoretical advantages of feed water heating have been realised in actual practice.

Mr. Robinson. — I am also of opinion that the heating apparatus is still in an experimental state and that the moment has not yet arrived to recommend it.

Mr. Van Schouwenburg. — The chief difficulties I have met with derive much more from the action of the pump than from the action of the heater itself. In consequence, I am of opinion that it is difficult to adopt general conclusions as to the advantages represented by the use of heating apparatus for the feed water.

Mr. Brévillé. (In French.) — For many years past the French Nord have fitted a certain number of feed water heaters to their locomotives. These have given us satisfaction from every point of view. I think, however, that certain distinctions should be made. First of all there is the pump.

Nobody I think contests the advantage that is derived from heating the feed water, for it gives an appreciable economy and increases the boiler power.

As regards the apparatus, by means of which the heating is obtained, I am of opinion that up to the present they are far from perfect. It is not our business however to praise one apparatus more than another, but rather should it not be the principle on which one opinion is to be expressed? I am convinced as far as I am concerned that there is an advantage in feeding the boilers with hot water. My experience has only been with a small number of boilers (about 70), but it is conclusive — with the reserve that the apparatus itself is not yet as it should be — in this sense that when a certain number of these feed heaters were taken down, the men working the engines asked very energetically for their return, although we had made them an allowance for the extra coal burnt.

On the other hand, I may say that these feed heaters were fixed on locomotives which were at the limit of their boiler power. The traffic having necessitated the loading of the trains being increased, there was a great deal of difficulty in keeping up with it, but with the heating of the feed this disappeared.

I think it has therefore been proved that its advantage is incontestable, but with the other delegates, I am quite of opinion that the problem has not been solved as far as the choice of apparatus is concerned, and it would be premature to show a preference for any one type, not only so as not to advertise any particular firm, but also to avoid giving an opinion as regards apparatus fed with a pump or an injector.

Mr. Gresley. — Trials carried out on the Great Northern Railway indicated some economy of fuel due to feed water heaters worked in conjunction with feed pumps, but the cost of maintenance was high. Drivers prefer exhaust steam injectors; they are simpler and more efficient.

Mr. Boulière, Greek State Railway. (In French.) — Though our trials of heating the feed water have not yet been very extensive, I think it right at least to give the results which have been obtained up to now on the different lines.

The Greek State Railways have recently fitted feed water heaters to ten of its most powerful engines : ***Mikado*** type which has two cylinders with simple expansion and superheat and a grate area of 35 square feet.

These locomotives work the heavy or express train service (especially that of the S. O. E.) on the Le Piree-Athens-Larissa line.

The system of heater used is that fed by means of a pump.

We were very sceptical at first as regards its success, for the following reasons :

On the one hand our line is very hilly, and the portion over which these fitted locomotives had to run for a distance of 220 miles is made up of :

about : 25 % of gradients 1 in 50 (of which 2 are 12.4 miles and 18.6 miles in length);
25 % of gradients 1 in 62;
20 % of gradients 1 in 100 to 1 in 66.

This profile necessitated a very variable system of feeding the water, and we wondered if the pump would have enough freedom of action to supply it automatically.

On the other hand our waters are of very bad quality (some classed at over 100), and it was to be feared that parts of the pump or heater would scale rapidly.

In order to form an opinion of the working of this apparatus and the economy that might be derived from it, we made trials over a period of two months.

These were carried out with the same locomotive, the same staff, the same quality of fuel and in as nearly the same atmospheric conditions as it was possible to get.

The average consumption of fuel per 100 English ton-miles worked out to 23.97 lb. with the injector, and 20.48 lb. with the pump, or a practical economy of 14.5 % in favour of the latter.

Generally speaking the apparatus worked satisfactorily. The pump alone automatically kept the boiler supplied; it started itself as soon as the regulator was opened, and slowed up as soon as the latter was closed.

The temperature of the feed water kept always between 207 and 212° F., whether on an incline, on the flat, or on descending gradients.

However, on long down slopes the temperature falls to 194° and even to 185° F., though the feed was at this time extremely reduced. This is due to the fact that our engines not being fitted with air brakes we have no exhaust steam from the air pump for feed water heating. To remedy this, we are proposing to use that given from the ejector of the Hardy brake, with which our engines are fitted.

We were able to maintain with the pump an average water level in the boiler, which was practically constant on the level as well as on steep gradients, and kept at the same time a pressure close on that of blowing off, and this with much less trouble than with the injector.

After each double journey the heater was cleaned, and according to the nature of the water supplied, about 90 to 130 lb. of mud was taken out. Up to the present no scaling up of the tubes has been noticed.

We have not yet made any special trials as regards back pressure in the cylinders, but it appeared to us that there was some change from the original working conditions, and though keeping the same area at the nozzle of the blast pipe, we fitted it, on the advice of the maker, with a crossbar so as to increase the surfaces in contact between the exhaust and the gases.

To sum up, the application of heating the feed water on our locomotives has given us a fuel economy of 14.5 %, greater ease in running the engine, and above all a noticeable improvement in the quality of the feed water.

The problem of softening the water has always been a very serious one for Greek railways, but it has never been solved, in spite of all the efforts that have been made. Heating the feed water appears to have found a solution which, if not completely successful, has at least reached a point that had never before been attained.

Mr. Vallantin. (In French.) — The first trials of heating the feed water on the Paris-Lyons-Mediterranean extend back to 1907, but it was only in 1919 that we had a sufficient number of locomotives fitted to enable us to form any definite opinion on the subject. In 1919 we had at our locomotive depot at Lyon-Vaise, 10 locomotives (eight wheel coupled with bogie and 33 square feet grate area) fitted with pump feed water heaters working goods trains between Lyons and Dijon or Lyons and Portes. The result agreed with those of Mr. Boulière, and we obtained an economy of 14 % in fuel.

After this very encouraging start, we decided to continue the trials, and ordered 100 feed water heaters, 50 of which were for engines indentical with the first 10, 25 for very similar ones (but not superheated) and 25 for the *Pacific* type of engine with simple expansion superheat and 4 equal cylinders. These *Pacifics* were the first we had put into service and are not so powerful as the compound *Pacifics* that were built later. It was thought that the addition of the feed heaters would bring them to the same level as regards power.

At the beginning, certain difficulties were met with on account of the exhaust, but none the less these *Pacific* engines were found to work much easier after they were fitted with the feed heaters.

The fireman puts the pump to work as soon as the train starts, and does not interfere with it during the journey of 125 miles. As far as he is concerned he has absolutely no longer to think of feeding the boiler with water, and his whole attention can be given to looking after the fire and helping the driver to keep an eye on the signals, which simplifies things considerably.

One important point to notice is that the enginemen are highly pleased with the arrangement.

Mr. Lacoin. (In French.) — I should perhaps give satisfaction in meeting the views which have been expressed on the subject by altering the words « to put into general use » to « extend the use of feed water heaters ».

Sir Henry Fowler. — I propose the following text :

« On some railways, feed water heaters and exhaust steam injectors have been introduced on a large scale.

« The results obtained are such as to warrant the extension of the use of these devices. »

— This text was adopted.

Meeting held on 25 April 1922 (morning).

Mr. G. GIBBS, IN THE CHAIR.

The President. — Yesterday we examined letters *A* and *B* of the question : « Economic production and use of steam on locomotives. » We pass on to letter *C* : Special devices.

Paragraph *a*) reads :

The trial of water tube boilers in competition with those of ordinary type has made no progress. Those made up to date have not enabled any definite conclusions to be arrived at. Even in the most favourable cases the advantages found, or anticipated, in coal consumption or cost of maintenance appear to be small.

— Adopted.

The President. — We reach paragraph *b* : « washing out boilers with hot water ».

M. Van Schouwenburg has the floor.

Mr. Van Schouwenburg. — I should be pleased, if you would allow me to ask the following question in discussing the pending subject :

The Dutch Indian Railway Company has made experiments with an apparatus in the boilers (somewhat similar to the Gölsdorf type) having the purpose to separate the scale out of the feedwater before this enters the boiler.

The use of such apparatus, to my knowledge, has given very interesting results.

I should be pleased to receive information on this subject from the delegates present here.

Sir Henry Fowler. — Apparatus of this type is only of use where scale is due to « temporary » hardness of the water, and not when it is due to « permanent » hardness.

Mr. Lacoin. (In French.) — We have fitted baffling plates in boilers somewhat extensively on the Orleans Railway. These take the form of small shelves on which the feed water falls and deposits a portion of its sediment before mixing with the water in the boiler and we have found that certain advantages were derived from the arrangement. A portion of the deposit is collected in the trays, but if this was very abundant it settled in other parts of the boiler, and in this case the baffles caused localisation of the sediment which was somewhat objectionable and necessitated putting in extra washout holes. In short, if the fitting in of these baffles is to a certain extent beneficial, on the other hand they bring about certain inconveniences which have to be put up with.

Mr. Crawford, Secretary of State, United States of America. — In America the washing of locomotive boilers with heated water may be regarded as the general practice at engine terminals where large numbers of locomotives are handled.

The modern plants for caring for locomotives are usually provided with the necessary apparatus to permit the use of heated water for boiler washing purposes.

In some instances water is chemically treated in the locomotive tenders but in localities where the water is very bad or where large quantities of water is to be purified the chemical treatment is done in the roadside storage tanks.

Mr. Brévillé. (In French.) — Last year the French Nord Company had to re-erect a certain number of locomotive sheds which had been completely destroyed during the war. We had therefore an opportunity of reconstructing them according to the latest designs, and thought we would profit by this circumstance to instal hot water washing out apparatus which had already given good results at other places. We decided therefore to go to Italy in order to examine plants fixed at various running sheds on the Italian State Railways, one of which the Congress visited last Friday, and from what we saw we arranged to fix similar apparatus at eight of our locomotive depots, which will become important centres as soon as their allotted number of locomotives has been delivered.

These plants, which were very rapidly fixed in position by the Italian engineer who was responsible for their erection, were put to work in October-November 1921. The trial lasted until they were in proper working order, but it is still relatively recent. The economy and technical advantages obtained, however, appear to us to have already been sufficiently proved by the results.

Formerly the water supply at certain of our stations was of very bad quality and the boilers could not be washed out with a sufficiently high pressure. With this new system, however, we have found that the running sheds are working under much better conditions than formerly. A beneficial influence was also immediately felt as regards tubes and tube plates, due to the washing out with hot water under this higher pressure.

I should point out that it is customary to stop our engines for as short a time as possible, but now that we have superceded our somewhat primitive washing out and filling up methods with the hot water system, the complete operation of washing out, filling and putting into service again can be accomplished in a maximum delay of four hours.

This, as far as we are concerned, is a point of great importance.

The value of these results became more apparent every day and are sufficiently convincing to decide us to extend the system to old locomotive depots which had not suffered from the war. In some of the smaller ones where these plants have been installed, they are working somewhat at a disadvantage from an economical point of view, because these depots, having been constructed for the use of 250 locomotives, have not been supplied with half that number up to the present.

To sum up, we may say that the French Nord has made good progress with the system of washing out with hot water, and is well satisfied with it.

Mr. Cassinis, Italian State Railways. (In Italian.) — With regard to filling and washing out locomotive boilers with hot water, about which several speakers have already given their views; I should like to say that the locomotive sheds at Mestre, Turin and St. Lorenzo at Rome on the Italian State Railways, have made trials in order to find out what advantage could be gained from this practice, and if it was possible to utilise the heat units contained in the steam and waste water blown off from the engines without having recourse to fixing a stationary boiler for the special purpose of washing out and filling the engines with hot water. We found out from these trials some interesting facts, to which I should like to call your attention. The experiments were made with emptying two locomotives together, which we found to be the method which gives the best results, at least as far as a small installation like that at St. Lorenzo, Rome, is concerned.

With two engines at a pressure of 35 1/2 to 57 lb. per square inch and 2 200 English gallons of water, it is possible to recuperate 85 to 90 % of 7 143 000 British thermal units, which is equivalent to 6 000 000, and gives to the feed tank a temperature of 167 to 176° F., and 122° F. in the washing out tank. By washing out and filling several locomotives daily with hot water, as can be done at St. Lorenzo, Rome, where 20 are filled per day, we have found that, taking into account the cost of installation and coal, a net saving of about 130 lires per day has been obtained. If in fact a calculation is made of the general expenses including the sinking fund, interest on capital, wear of belts and mechanical contrivances, in addition to the cost of electric power from the Central Station, we arrive at a total of 100 lires per day, whilst an economy of 1 500 kgr. (3 300 lb.) of coal at 150 lires per ton gives an economy of 229 lires or a net saving of 130 lires per day. If we admit that the apparatus cannot be at work every day in the year and may be stopped three days per month, either for cleaning out purposes or for a temporary stoppage in the supply of power, and if we multiply this sum by the 329 effective working days, we obtain for the Administration a yearly saving of 33 891 lires or 51 % of the cost of the coal necessary to produce the same result, that is to say, to wash out 20 engines of different classes per day with hot water at 122° F., and fill them at 167° F. By washing out and filling locomotives with hot water as soon as they have worked their appointed trips, the advantage of having a more rapid service is obtained, and there are also economies as far as repairs are concerned; a result which is generally admitted by everyone.

The figures just given have been calculated by taking the average thermic efficiency to be 80 %; one ought to be able, by means of suitable arrangements, to increase this percentage to 85 %, which would allow one to be absolutely certain of effectively realising the saving I just mentioned, of the 1 500 kgr. (3 300 lb.) per day of coal, which otherwise it would be necessary to use if the boilers were washed out and filled with hot water.

These figures allow one to say that it is possible to obtain a real economy in the cost of fuel.

Mr. Lacoin. (In French.) — As regards this subject, there are several questions which should be considered successively. First of all, is there any advantage at all in washing out boilers with hot water by means of any sort of apparatus?

With regard to this, I think everyone will agree that it is preferable to wash out boilers with hot water, rather than with cold. The work is better done, and it is also a desirable thing, from the point of view of the upkeep of the boilers.

The second question is to find out if there is any advantage in the use of plants for washing out with hot water recuperated from the heat contained in the hot water and steam of the locomotives to be washed out.

These are two very different questions.

As regards the second one, there is one point which will I belive be accepted by all, and that is, these plants are costly as they earn nothing directly, but at the same time are able to pay for their upkeep whenever the railways require to use the locomotives again quickly. By this means two economies are being made: one which results from washing and filling up with hot water and which is directly connected with the coal consumption and the maintenance and satisfactory washing out of the boilers, and the other which gives a better use of the locomotives, which are enabled to be put back into service quicker.

As far as I can see, these are the chief reasons why washing out with hot water is so extensively used in America and on those lines where it has been an advantage to use the engines again as soon as possible after they have finished a trip.

The third question is to know whether there is any advantage in making use of this apparatus on lines where locomotives are not run by successive sets of men and where they have all the necessary time for washing out at their leisure, and the fact of having hot water to do so is not an advantage in getting them into service again quickly.

It is on this point that opinions may differ, and it would be interesting to know from those delegates who have fitted this form of plant on their railways what percentage of coal economy they obtain by their use. Are there for instance apparatus the first cost of which was 400 000 fr. and by means of which 50 000 fr. per year have been saved? This percentage saving of about 12 % appears to me a fair one to expect, but certain railways would consider that at the actual money rate an installation which only returned 12 % of its cost would hardly be worth consideration.

Mr. Weiss. (In French.) — The Swiss Federal Railways have fixed a plant for washing out boilers with hot water at their Zurich locomotive depot. Unfortunately it is not yet quite in working order, and I cannot therefore give any precise information on the subject.

I should like, however, to say a few words on a somewhat important point.

Washing out with hot water is in my opinion most necessary for boilers fitted with steel fireboxes. If I am properly informed, it is for this reason that this method of washing out is so prevalent in America and in Europe, where steel fireboxes are in use. The aspect of the whole question changes where copper fireboxes are concerned.

Mr. Gresley. — One of the first plants to be installed in England was on the Great Northern Railway at their London engine sheds in 1910. It was supplied by the Economical Boiler Washing Company. Subsequently two other running sheds, at each of which upwards of 200 locomotives are stationed, were equipped similarly. The results were very interesting from the point of view of getting better use out of the locomotives. At stations where the water is not very good engines must be washed out twice a week, and must be out of service for eight or nine hours each time, whereas if hot water washing can be utilised only about two hours are required before they can be put into service again. Undoubtedly the value of the arrangement depends to some extent on the nature of the boiler water. As to the effect of hot water washing on the cost of maintenance of engines I have been able to see no tangible advantage, but there is no question that the value of hot water washing out is considerable particularly if the boiler water is bad in that it increases the availability of engines.

The President. — I remark with pleasure that a number of interesting particulars have been supplied on the washing out of boilers with hot water.

If no one else wishes to speak, I put to the vote the conclusions of paragraph *b* thus stated :

There is an advantage in washing out boilers with hot water, particularly when it is necessary that they should be stopped for as short a time as possible. The washing out plants with auxiliary boiler and fixed water and steam piping allowing the recuperation of the steam and water for locomotives are used to advantage in certain particular cases, especially where the cost of water is very high, but their price and complication seem to be against their extensive use on systems where the engines have fixed bookings.

— These conclusions are adopted.

Paragraph *c* :

Brick arches improve combustion, and their use has become general.

— Adopted.

DISCUSSION AT THE GENERAL MEETING

Meeting held on 27 April 1922 (afternoon).

Mr. R. DE CORNÉ, HONORARY VICE-PRESIDENT, IN THE CHAIR.
GENERAL SECRETARIES : Mr. J. VERDEYEN; Mr. E. FRANZA; Sir HENRY FOWLER.
ASSISTANT GENERAL SECRETARY : Mr. N. GIOVENE.

Sir Henry Fowler, *general secretary*, reads the

Report of the 2nd section.

« (See *Daily Journal of the session*, No. 8, p. 4.)

« THE PRESIDENT proposed to take as the basis of discussion the conclusions put forward by Mr. LACOIN, the special reporter.

« *Section « A ». — Paragraph « a ».*

« Mr. VAN SCHOUWENBURG (*Dutch East Indian Railways*) wished to say that even with slow stopping trains they had obtained good results with locomotives fitted with single return superheater elements in smoke tubes 2 1/2 inches in diameter. It was not difficult to clean out the tubes, probably because wood was the only fuel used for their locomotives.

« Mr. LACOIN (*special reporter*) said that on a certain number of the French railways they had done away with the dampers without trouble developing. This also made it easier to clean the smoke tubes.

« Mr. WEISS (*Swiss Federal Railways*) stated that on the Swiss Federal Railways they had also abandoned dampers without trouble arising. With locomotives with eight coupled wheels they obtained a steam temperature of 752° F. when running, and 572° F. when shunting.

« Sir Henry **Fowler** (*Midland Railway*) said that they too had dispensed with dampers without difficulties arising.

« M. George L. **Bourne** (*New York Central Railroad*). — In America they had generally retained the dampers. Superheating with small smoke tubes as mentioned by Mr. Van Schouwenburg was not employed. Any fear of the tubes being blocked had not materialised; they were blown out from the firebox end.

« Mr. **Vallantin** (*Paris-Lyons-Mediterranean*) said that his company had locomotives with piston valves and Serve boiler tubes 70 mm. (2 3/4 inches) in diameter. In order not to have to replace the tube plates, they had obtained superheated steam by placing small diameter elements in plain smooth tubes of this diameter (2 3/4 inches). These engines when altered showed an economy of fuel of about 17 to 24 %, and did not give any trouble. The return bends in the small elements were originally placed so as to lie 13 inches from the tube plate at the firebox end; this distance however had been increased to 19 1/2 inches in order to prevent the ends becoming burnt.

« Sir Henry **Fowler** said that his railway had not been troubled with the tubes becoming burnt, and this he attributed to the care taken in manufacture.

« Mr. **Robinson** (*Great Central Railway*) stated that the Great Central Railway had 500 locomotives without dampers and that they gave every satisfaction. Superheaters constructed of small tubes placed in tubes of 76 mm. (3 inches) diameter had been used to overcome trouble arising from cracks in the tube plate between the large tubes. With regard to the burning of the ends of the tubes, this had been overcome by employing an end made of an iron stamping, but trouble had only occurred with oil fired locomotives.

« Mr. **Kejr** (*Czecho-Slovakia State*) gave the results of trials made in Czecho-Slovakia.

« Mr. **de Vargas** (*Northern Railway of Spain*) said that in Spain they had had trouble with superheater smoke tubes with boilers having steel fireboxes, but with copper fireboxes no difficulty had been experienced.

« *Section « A ». — Paragraph « b ».*

« Mr. **Bourne** stated that in America they had 42 000 locomotives superheated and 20 000 which were not, but of this latter 50 % would not be altered owing to their age.

« Mr. **Lacoin** proposed that the words « may possibly be advantageous » be superseded by, « may frequently be advantageously carried out ».

« Mr. **Weiss** stated that in Switzerland superheating was first applied in 1905; in 1910 the first locomotive had slide valves replaced by Lentz valves. In 1913 they began to fit up all the balanced slide valve engines as superheaters, the practice being to use forced lubrication, the oil being forced into grooves in the cylinder port faces. The valves are of cast iron or preferably of bronze. Actually a hundred locomotives had been altered.

« Mr. **Robinson** and Sir Henri **Fowler** said that they had had no difficulty in using ordinary slide valves with superheated steam.

« Mr. **Van Schouwenburg**. — There

are two points to consider : Theoretically superheating gives an economy of coal, but if to obtain this it is necessary to alter the boiler and the cylinders, as he thought it was, to get the greatest possible advantage, the question is to ascertain if the alteration still results in a financial economy.

« Mr. Weiss. — The Swiss Federal Railways only alter locomotives of recent types.

« The economies realised, which amount from 10 to 12 %, pay for the cost of alteration in from a year and a half to two years.

« Mr. Bourne. — With slide valves, the difficulty is not only one of lubrication, but arises from the valves becoming deformed. Replacement of cylinders is not absolutely necessary without one wishes to increase the tractive effort; this is not always required. The improvement ought always to result in an increase in the capacity of the boiler.

« Mr. Lacoin. — The Eastern Railway of France had carried out trials with slide valves and obtained satisfactory results.

« Mr. Stalder (*Swiss Government*) and Mr. Robinson pointed out that the successful use of slide valves had been fully established.

« *Section « A ». — Paragraph « c ».*

« Mr. Lacoin thought that the discussion ought to be directed to the application of compounding to very powerful locomotives.

« Mr. Bourne. — In America compounding is only employed on Mallet locomotives.

« Mr. Vallantin did not consider the question of compounding as definitely established. In France, three railways were about to exchange locomotives with a view of carrying out methodical tests.

« Sir Henry Fowler said that the Midland Railway had three cylinder compound locomotives using superheated steam.

« Mr. Robinson had obtained good results with four cylinder superheated compounds.

« Mr. Bréville (*Northern Railway of France*) had the same experience.

« Mr. Weiss. — The results of trials made on the Swiss Federal Railways show that four cylinder superheated compound engines are preferable to superheated simple engines with four equal cylinders. They are also preferable to two cylinder engines when the varying stress on the rails is considered.

« Mr. Gresley (*Great Northern Railway*) thought that it was not desirable to apply superheated steam to existing compound engines. In England the use of three cylinder simple expansion engines using superheated steam was increasing.

« Mr. Lacoin said he was in a position to state that two cylinder locomotives with simple expansion and superheated steam had a consumption 5 % less than compound superheated locomotives.

« Mr. Bourne said that one must not only consider the coal economy, but also the cost of maintenance.

« Mr. Bréville pointed out that coal economy is important because the work which the boiler can do limits the power that can be obtained from a locomotive.

« A discussion took place on the exact

wording which should be used for the summary, in order to make it accord with the views expressed.

« *Section « A ». — Paragraph « d ».*

« Mr. Bréville suggested that the exact saving that could be obtained by employing superheated steam to simple expansion locomotives should be inserted. This suggestion was approved of and accepted by Mr. Lacoin, who proposed that from 10 to 20 % should be inserted.

« No discussion arose on paragraph *e*, and the discussion was commenced on

« *Section « A ». — Paragraph « f ».*

« Mr. Van Schouwenburg enquired as to whether experiments carried out without air relief valves fitted at the header had led to element ends burning; he also asked if trials had been made with steam circulating valves only.

« Mr. Weiss said that bye-pass valves and air relief valves had been tried on the Swiss Railways, and that now air relief valves are used on high pressure cylinders, and bye-passes on low pressure cylinders.

« Mr. Gresley said that the Great Northern used air relief valves only and placed them on the headers. This had been their practice for ten years and had given complete satisfaction.

« Mr. Robinson stated that his experience was the same.

« Paragraph *g* did not give rise to any discussion and Mr. Lacoin read the new text proposed for section *A*, which was adopted without alteration.

« *Section « B ».*

« Mr. Lacoin proposed that in place of the conclusions which he put forward in his report proper, a text should be adopted very similar to that given in the special report.

« Sir Henry Fowler and Mr. Robinson thought that not sufficient actual experience was yet available for this to be agreed to.

« Mr. Van Schouwenburg asked what had been the difficulty with the pumps.

« Mr. Bréville thought that the principle was agreed on, the question being with the apparatus. The staff is favourable to the use of this type of apparatus.

« Mr. Gresley. — The pump is preferable from the point of view of economy, but when repairs are taken into account, the exhaust steam injector is the best.

« Mr. Boulière (*Greek State Railways*) said that very satisfactory results had been obtained in Greece with feed water heaters, especially with bad waters. The coal economy had been 14.5 %, but he wished to emphasise the importance of preventing scale in the boiler.

« Mr. Vallantin. — On the Paris-Lyons-Mediterranean they had also found an economy of 14 % on ten locomotives which had been fitted as an experiment with feed water heaters. This result had decided them to extend the system to a hundred other locomotives. The piping required was easy to fix, and the staff was very satisfied with the apparatus.

« Mr. Lacoin and Sir Henry Fowler proposed that the wording should be altered, and that suggested by Sir Henry Fowler was adopted.

« *Section* « *C* ».

« Paragraph *a* did not give rise to any discussions.

« With regard to paragraph *b*, Mr. VAN SCHOUWENBURG said that on his railway they had experimented with the *Gölsdorf* apparatus. This caused scale to be deposited in the apparatus itself and not in the boiler, and he thought mention should be made of this apparatus in the summary.

« Sir Henry FOWLER pointed out that apparatus of this type is only of use where scale is due to « temporary » hardness of the water, and not when it is due to « permanent » hardness.

« Mr. LACOIN had used the method of feeding the water into the boiler by which the deposit collects on two plates placed in the steam space. This apparatus gives good results, but entails a certain amount of trouble in removing the mud when the water is bad.

« Mr. CRAWFORD (*United States Government*) said that washing out with hot water is general in North America, where it is also the practice to soften the water.

« Mr. BRÉVILLÉ stated that trials with washing out with hot water had been made in eight sheds of the Northern Railway of France. The installations were similar to those put into service in Italy in October 1921 and have given very satisfactory results, especially from the point of view of quickness in washing out and time saved in raising steam again.

« Mr. CASSINIS (*Italian State Railway*) spoke of the favourable results obtained at the locomotive sheds at San Lorenzo with the method of washing out with hot water and recuperating the heat. He gave figures showing the economy realised, and pointed out that the tube plates were kept in a better state of repair.

« Mr. LACOIN. — The principle of the advantage of washing out with hot water is not disputed. What one wants to know is where one can use as a practical proposition the heat recuperated from the steam and the water emptied out; the plant that allows of this being done is very expensive. Without doubt recuperation is of greater interest where locomotives are pooled.

« Mr. WEISS. — The Swiss Railways have a plant at Zurich. He thought that the practice in America is chiefly justified by the use of steel fireboxes.

« Mr. GRESLEY. — The Great Northern put in their first installation in 1910. The results have been so satisfactory that they have equipped two other sheds at each of which 200 locomotives are stationed. The chief advantage is that greater use can be obtained from the locomotives.

« THE PRESIDENT proposed that the text of the special reporter be adopted. The concluding paragraph *c* did not give rise to any discussion.

« The summary of this question, which it was decided should be put forward to the general meeting, was as follows. »

The President. — This is the

Final summary.

« SECTION *A* : SUPERHEATER STEAM.

« *a*) Superheating is universally adopt-
« ed in the construction of locomotives
« for passenger and freight trains. It
« has not yet been exclusively applied to
« suburban traffic, but the results given
« in these services have been satisfactory,
« especially when the smokebox dampers,
« which cut off superheating when the
« regulator is closed, are removed.

« *b*) The conversion of saturated to superheated steam engines may frequently be advantageously carried out when these are in the shops for repairs, especially with powerful engines of recent types.

« *c*) Owing to the superheat, the use of two cylinder single expansion and superheater locomotives has increased. For powerful engines the preferences of the railways are divided between two cylinder single expansion, the four cylinder compound and the three or four cylinder single expansion all with superheaters.

« *d*) The fuel economy obtained by the application of superheat to the single expansion engines may be estimated on the average to be for ordinary working conditions about 10 to 20 %. This economy however varies considerably, according to the work done and the condition in which the parts are kept, and it is necessary to pay more attention to upkeep than with saturated steam engines.

« *e*) The special arrangements adopted originally for the valves and pistons of superheat engines have a tendency to become more uniform, simpler and more like those used on saturated steam locomotives. On new locomotives piston valves are exclusively used for the high pressure cylinder and packings with sliding joints and outside air cooling for rods acted on by live steam. The area of the cylinder relief valves has also been increased. These are the only special arrangements, the necessity for which has been universally recognised.

« The same tendency towards simplification is apparent in the instructions given to the drivers.

« *f*) Some administrations use both air relief valves and bye-passes. The necessity for both of these does not appear to be yet completely established.

« *g*) Corliss and similar type valves and the uniflow arrangement have made no progress.

« SECTION *B* : FEED WATER HEATER.

« On some railways feed water heaters and exhaust steam injectors have been introduced on a large scale.

« The results obtained are such as to warrant the extension of the use of these devices.

« SECTION *C* : VARIOUS DEVICES.

« *a*) The trial of water tube boilers in competition with those of ordinary type has made no progress. Those made up to date have not enabled any definite conclusions to be arrived at. Even in the most favourable cases the advantages found, or anticipated, in coal consumption or cost of maintenance appear to be small.

« *b*) There is an advantage in washing out boilers with hot water, particularly when it is necessary that they should be stopped for as short a time as possible. The washing out plants with auxiliary boiler and fixed water and steam piping allowing the recuperation of the steam and water for locomotives are used to advantage in certain particular cases, especially where the cost of water is very high, but their price and complication seem to be against their extensive use on systems where the engines have fixed bookings.

« *c*) Brick arches improve combustion, and their use has become general. »

— The general meeting ratified this summary.

[621 .13 (.73)]

APPENDIX 1.

The development of the steam locomotive in North America,

By G. L. BOURNE,
CONSULTING ENGINEER, NEW YORK CENTRAL RAILROAD.

1. The development of the steam locomotive in North America, over the ten year period (1910 to 1920) is the result of study and the improved design of various factors, which may be outlined in a general way as follows :

a) Handling and combustion of fuel;
b) Evaporation of water;
c) Treatment of steam;
d) Distribution and use of steam;
e) Transmittal and conversion of power.

2. By the proper selection and use, of part or all, of the devices affecting these factors — consideration of their limitations and field for use being determined by careful analysis and experimental application — the development in size, power and economy of American locomotives has been marked during the period considered.

3. The reduction in the amount of steam and fuel per H. P. hour has resulted from the use of fuel in a more effective manner in the firebox, by provision for extracting a larger amount of the available heat from the gases and transferring them to the water while passing through the boiler; by transforming the steam through superheating into a more effective working medium, permitting its use more economically in the cylinders which have been designed, with greater attention to the free passage of the steam into and out of the cylinders; by the arrangement of the power transmitting mechanism of the locomotive in a manner which will permit still larger percentage of the power, than formerly appearing at the tender coupling in the form of drawbar pull.

4. Many and varied arrangements for the several different factors outlined above have been developed and tested. Many other devices intended to produce the same results have been made available. A discussion of the particular forms of these different pieces of apparatus and features of design — both successful and unsuccessful — is not permitted in this discussion.

5. In order to show the trend of development, which has been described in general terms above, the following table has been prepared

6. The locomotives which have been selected for purposes of comparison, are believed to be representative of the period of development. In 1909 and 1910 the Mallet engine, without superheaters, was by no means uncommon, but very shortly it was recognized that superheaters must be a part of a successful Mallet type locomotive. During the last ten or eleven years no Mallet engine has been built without a superheater. Few, if

TABLE.

—	*Mallet.*		*4-6-2*		*4-8-2*		*2-8-2*		*2-10-2*	
	1909-10	1919-21	1909-10	1919-21	1919-21	1922	1909-10	1919-21	1922	1919-21
Boiler pressure	210	240	200	190	185	200	200	180	200	190
Superheat (degrees) . . .	...	200	...	200	250	300	...	250	300	200
Steam per indicated H. P. .	23.5	18	27	19.5	18.5	17.7	27	18.5	17.7	19.5
Coal per indicated H. P. .	3.5	2.8	4.0	3.0	2.8	2.6	4.0	2.8	2.6	3.0
Maximum cylinder in H. P.	2 060	4 020	1 614	2 312	2 613	3 378	1 920	2 542	2 824	3 082
Weight on drivers . . .	262 350	480 000	160 150	182 000	234 000	245 000	201 000	240 500	246 000	300 000
Total weight of engine . .	305 150	540 000	234 900	296 000	343 000	365 000	260 500	320 000	336 000	390 000
H. P. per 1 000 lb. / Drivers weight. . . .	7.85	8.37	10.1	12.7	11.15	13.75	9.55	10.59	11.5	10.3
H. P. per 1 000 lb. / Total weight. . . .	6.75	7.44	6.87	7.8	7.63	9.24	7.37	7.96	8.42	7.93
Lb. driver weight per indicated H. P.	127.2	119.5	99.3	78.1	89.6	72.7	104.8	94.5	87.2	97.3
Lb. of engine weight per indicated H. P. . . .	148.2	134.0	145.5	127.2	131.5	108.2	135.6	126	119	126.4

any, during this period have been built without a brick arch. Successive developments and improvements in running gear, cylinder arrangement, steam piping, and other factors, including stokers, have permitted the increase in capacity and effectiveness of this type of locomotive.

7. The 4-6-2 Pacific type locomotive was, in 1910, commonly fitted with superheaters, but has been growing in size and has because of the demands for greater capacity, been, to some extent, laid aside in favor of the 4-8-2, or Mountain type locomotive.

8. In a similar way increased power demands have caused railway men to go from the 2-8-2 Mikado locomotive to the 2-10-2 Santa Fe type engine. The Mikado engine in 1910 was quite frequently built without superheaters. The Santa Fe type, as developed, has, without exception, been fitted with superheaters, and has included several, if not all, of the other factors which make for economy in locomotive operation.

9. What has been accomplished in this ten year development pediod, not only as to the decrease in steam and fuel per H. P. hour, but also in the weight of locomotive per H. P. hour, may be noted from the table.

10. The New York Central Lines have, in the opinion of its motive power officials, contributed to the development referred to in the foregoing. Some of its locomotives are included in table 1. That this road has made full use of improvements which go to make up effective locomotive operation, is well known. One illustration of this will suffice. On the New York Central, and its allied roads, there are, at the present time, more than 4 400 locomotives fitted with superheaters, being an increase of 2 100, or 90 % since the beginning of 1915.

11. That progress is still to be expected will be clearly evident from the figures shown for the 1922 : 4-8-2 and 2-8-2 type locomotives shown in the table. These engines may be considered as typifying the effort to co-relate the various factors which have been alluded to, and by the incorporation of as many of them as the type of locomotive, and the service it is designed for, permit, will make a marked decrease in the fuel consumption and in the number of pounds of locomotive per H. P. Quite possibly, before this discussion appears in the printed proceedings, these engines will have passed through their trials and be in operation.

12. That locomotive development in the United States and Canada has been going on, in spite of the handicaps incident to the disturbing conditions of the Great War, will be evident from the foregoing. That the development during the next ten year period (1920 to 1930) will show an equal, if not greater, improvement, may be confidently expected.

[621 .138.2]

APPENDIX 2.

Apparatus for bringing coal forward on locomotive tenders, Halla-Haken system (Patented),

By Paul KOLLER,
ENGINEER AT THE MINISTRY OF CZECHO-SLOVAKIAN RAILWAYS.

Figs. 1 to 3, p. 324.

When coal lying in the space in the front part of the tender and immediately accessible to the fireman's shovel has been used up, it is necessary to bring that forward which is lying at the back. Up to the present this operation is done by hand, and the fireman, overheated by his work and the heat from the firebox, is obliged to enter the coal space to rake the fuel forward even when it is freezing, snowing or raining. This is one of the chief causes of the frequent illnesses of firemen, and in order to relieve him of this work, a special service of labourers is employed at large stations to shovel forward the necessary coal during stoppages. This is a somewhat unsatisfactory method, and its cost is relatively high.

This difficulty can only be got over by the introduction of a mechanical conveyor which can bring the coal forward without much effort on the part of the fireman (1).

Two Czecho-Slovakian engineers, Messrs. Halla and Haken have studied this problem since 1914, and after trials, have finally succeeded in getting out a suitable arrangement which is now working on the Czecho-Slovakian Railways and giving very satisfactory results.

It is evident that an apparatus of this kind should fulfil the following main conditions :

1° It must be possible to bring all the coal contained in the coal space up to the fireman's shovel, even that which is lying in back corners;

2° The fireman should be able, at any time, to bring to the front the quantity of fuel he requires;

3° The kind of coal (small or large pieces, dust, etc.) must not influence the efficiency of the conveyor;

4° The conveyor should work, even under the most unfavourable atmospheric conditions, during frost, etc.;

5° Loading the tender must not be made more difficult, and the working of the conveyor must be as simple as possible.

In June 1918 the firm of Breitfeld Daněk & Co., Prague, submitted to the Ministry of Railways a device which fulfilled these various conditions, and was accepted. The first conveyor was delivered in March 1919 and fixed on tender No. 156.1650 of the Czecho-Slovakian Railways. In principle, it takes the form of a travelling bunker, but without a front end, and the bottom of which is a conveyor platform made up

---

(1) In Great Britain the majority of the railways arrange the slope of their tenders so that the coal automatically comes forward as the front portion is used. (*English Editor.*)

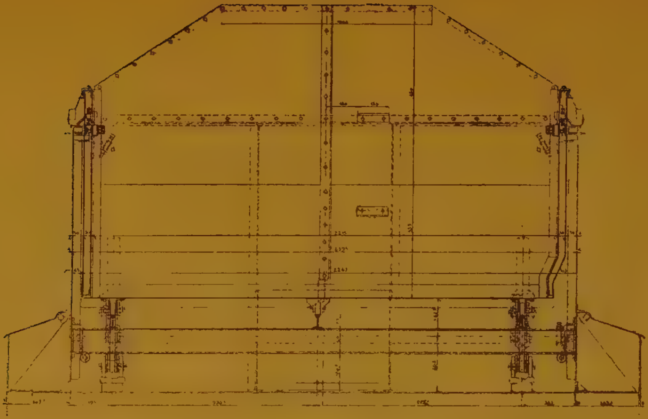
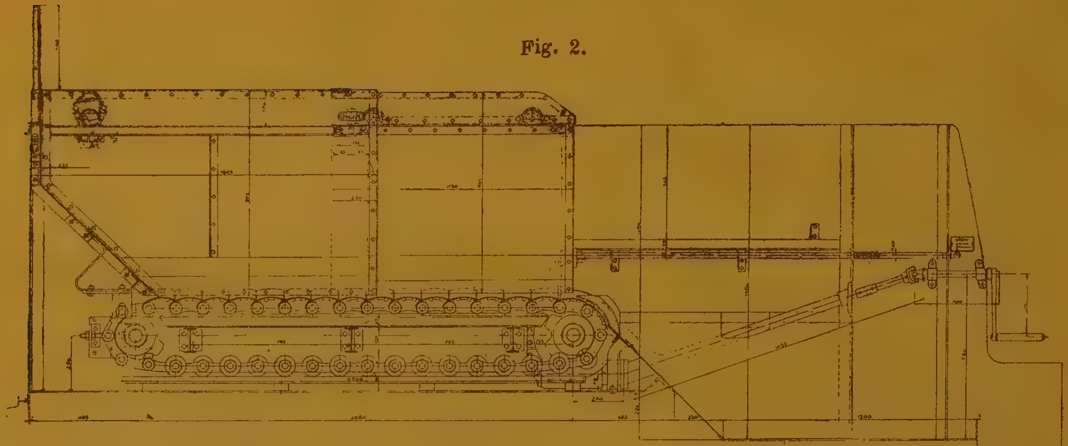


Fig. 1.

Fig. 2.



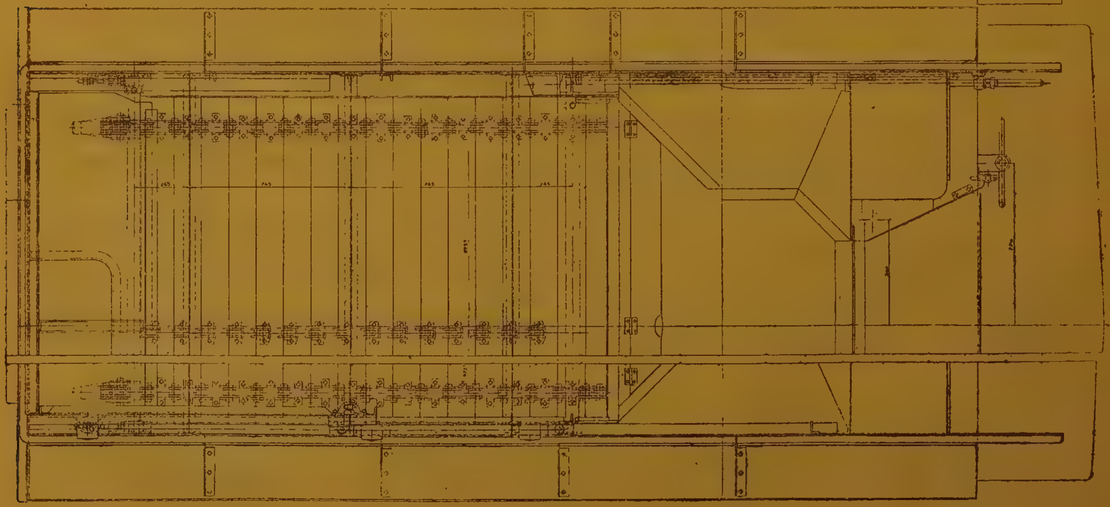


Fig. 3.

Figs. 1 to 3. — Apparatus for bringing coal forward on locomotive tenders, Halla-Haken system.

in sections of steel plates, and side walls being made of plates freely suspended on rollers sliding on the top edge of the tender side plate. The weight of the coal forces these plates against the curved ends of the conveying plates.

The moving floor on a six-wheeled tender is made up of 17 transverse plates 3/16 inches (5 mm.) thick and 7 1/4 inches (185 mm.) wide rivetted on to two Galle chains (each of thirty-five links 5 1/8 inches (130 mm.) between the joint pins). The length of each floor plate is 7 ft. 4 1/2 in. (2 250 mm.), and their raised ends make a support for the side plates of the travelling bunker. The Galle chains move forward or backward on cog wheels so that the whole flooring acts like an endless band. The convex shape of the floor plates correspond to the diameter of the wheels carrying the Galle chains, and at the time they pass over the wheels they form a cylindrical surface in such a way that the play between the cylinder and the inclined plate down which the coal falls is reduced to about 5/32 inch (4 mm.).

The Galle chain wheels are fitted on two transverse shafts, the bearings for which are fastened to the tender sides. The two back bearings and the right hand front one are adjustable in order to ensure the shafts being parallel and to allow of the tightening of the chains when necessary. The front left hand bearing (nearest the fireman) is a fixture completely closed in by the tender side and contains a helical gearing giving a transmission ratio of 1 : 42. The screw is placed in an oil bath and supported by ball bearings.

A cranked handle turns the screw by means of an obliquely fixed shaft and two universal joints, and on tenders of great length there is also a chain in order to transmit the power required.

In order that the movable flooring shall not bend under the weight of coal, especially when the chains are somewhat worn, the rollers of the Galle chains run on rails 2-9/16 inches (65 mm.) deep, which are carried on three cross bars rivetted of the tender sides.

The inclined plate on which the conveyor discharges the coal forms also a cover which can be lifted from time to time to remove the coal dust which falls through the play between this plate and the travelling platform.

The travelling bunker is fitted with two plates on each side (three on very long tenders) which can slide one behind the other. These plates, as mentioned above, are not in any way fastened to the conveyor and bear only against its curved ends. This contact ceases as soon as the side plate passes beyond the front shaft of the Galle chains, and the flooring, following the chain and the plates, continues to advance.

The back side plates are drawn along by the Galle chains, which are fitted for this purpose with special contrivances attached to the chain pins. The sloping bottom plate at the far end is fixed at the bottom to the back side plates.

The spaces between the sides of the moving bunker and the tender are protected against coal entering.

The back position of the conveyor is shewn by means of a simple indicator fixed near the winch handle, and is made up of a rod carrying two stops which strike against the sides of the travelling bunker in its back and front positions. By this means the rod which is fitted with a pointer indicates the two extreme positions of the bunker.

The front corners of the flooring are closed by means of plates inclined to an angle of 45°. The coal falls automatically into the space within the reach of the fireman.

The weight of the conveyor complete is about 4 200 lb. (1 900 kgr.), or 11 to 12 % of the total weight of an empty six-wheeled tender. The working of the conveyor is extremely simple and requires no special experience. After having used the front coal in the tender, the fireman turns the handle several times and the coal commences to come forward, the front part falling by means of the inclined and corner plates easily within his reach. This operation is repeated 4 or 5 times during a journey. A hundred turns of the handle are necessary to bring the conveyor from the back to the extreme front position.

If the handle of 11 7/8 inches (300 mm.) radius is turned at the rate of 2 ft. 7 1/2 in. (0.80 m.) per second with a force of 22 lb. (10 kgr.), it will take five minutes to bring the bunker from its initial position to the extreme limit of its travel. This light additional work for the fireman would be that required for a journey of about 60 miles (100 km.) with a 700 t. goods train and using a bad quality of coal.

At the end of the journey the fireman winds the conveyor back to its original position by turning the handle in the reverse direction, thus leaving the bunker ready for reloading.

After trials which extended over a year, the Czecho-Slovakian State Railways ordered a larger quantity of conveyors of this type.

[621 .133.7 & 621 .138.3]

APPENDIX 3.

Note on the hot water washing out plant at the locomotive shed at St. Lorenzo, Rome,

By R. CASSINIS,

ENGINEER.

The hot water washing out plant at St. Lorenzo, Rome, which has been worked spasmodically since the first trials carried out from 23 to 25 March 1922, is an installation capable of giving a real benefit and considerable economy in coal, if the washing out and refilling is carried out by hot water from a suitable boiler. In order to obtain these results, it is necessary to empty as many boilers as possible in the twenty-four hours, and thanks to the installation of this plant, it is possible to wash out all the locomotives in the two sheds at the depot, goods, passenger and shunting.

Bearing in mind the trips and booked hours of return to the shed, it is possible to arrange for the emptying of the boilers two or four at a time. The washing out and filling up has to be carried out in such a way as to use the recuperated heat immediately, and there need be no delay in refilling the boiler after it has been washed out.

Up to the present time the depot has made use of the heat of the water blown off and of the exhaust steam of the locomotives arriving at shed A. The average number of boilers blown off, washed out and filled up, is given in the following table, in which is also shown the heat units necessary to wash out at 122° F. and fill up at 167° F. and the coal necessary to produce this heat as well as the resulting cost of fuel.

LOCOMOTIVES. — TYPE.	Average number		English gallons of water used for		Calories necessary to raise the water to the required temperature		Equivalent coal (Westphalian of inferior quality giving 13 680 British thermal units per lb.)	Cost of coal (150 lires per ton delivered at the Italian depot).
	washed out.	refilled.	washing out.	refilling.	of 122° F.	of 167° F.		
							Lb.	Lires.
685	5	5	5 500	7 100	347 200	7 678 700		
680	1	1	880	1 320	555 600	1 423 800		
625	2	2	1 320	1 940	833 300	2 095 300	1 623.44	110.45
875	2	2	880	1 300	555 600	1 401 800		
835	1	1	880	560	555 600	607 200		

The result therefore is to save a total of 110.45 lires per day on the cost of the coal, which is small compared with the daily expense of working and for the installation of the hot water plant, estimated as follows :

General charge for interest and depreciation on capital (forty years for the structure and ten years for the machinery) taken at 6 % on 450 000 lires.	27 000 lires per annum.
Cost of supplying new belts (four per annum, each 8 m. (26 feet) long at an average cost of 75 lires per metre.)	2 400 — —
General expenses for repairs to plant, watchmen and contingency charges, etc.	5 400 — —
Electrical energy	1 650 — —
Total. . .	36 450 lires per annum.
Daily expenditure : about,	100 lires.

The resulting economy of 110.45 lires on the fuel compared with the expense of 100 lires does not constitute an appreciable benefit for the Central depot, but the real benefit accruing is considerable if one deals with locomotives types 735 or 740, and if one washes out locomotives of type 835 each day in shed B of the depot being dealt with.

One sees that washing out and filling up six locomotives belonging to types 735-740 and three locomotives of type 835 gives practically the same saving in fuel for washing out with hot water under the same conditions as that given in the preceding table, and this is shown in the following table :

LOCOMOTIVES. — TYPE.	Average number		English gallons of water used for		Calories necessary to raise the water to the required temperature		Equivalent coal (Westphalian of inferior quality giving 13 680 British thermal units per lb.)	Cost of coal (150 lires per ton delivered at the Italian depot).
	washed out.	refilled.	washing out	refilling.	of 122° F.	of 167° F.		
							Pounds.	Lires.
735 or 740	6	6	7 930	8 320	5 000 000	9 000 000	1 488.12 1 587.33	
835	3	3	1 980	1 680	1 250 000	1 821 500	253.53	118.50

Adding the saving of 118.5 lires to the 110.45 lires, as previously shown, we obtain a total in the neighbourhood of 229 lires, which represents a real saving of 129 lires per day over the daily expense.

Supposing that the central shed is closed each month for three days owing to a temporary failure of the electrical current and for cleaning out the tanks and reheaters, making a total of thirty-six days per year, the value of the fuel saved works out at 229 × 329 that equals 75 341 lires, which, allowing for an annual expense of 36 450 lires, gives a saving to the Administration of 38 891 lires, which is 51 % of the value of the coal which it would be necessary to use to obtain the same result, that is to say, the washing out at 122° F. and refilling at 167° F. of twenty locomotives of various types. In addition to this the coal which one saves during the month for each locomotive emptied, washed out and refilled, deducting the three days in which the plant is not working, is equal to

76.3 kgr. × 27 = 2 060 kgr. (4 542 lb.)

One has previously shown that to wash out and refill twenty locomotives per day requires 1 526 kgr. (3 364 lb.) of coal. The following table, however, shows that this figure is equivalent to the heat recuperated in the water blown off and the exhaust steam obtained from these twenty locomotives.

Type and number of locomotives washed out (Water level 4 inches and pressure 42.67 lb. per square inch.)	British thermal units in the water blown off and steam exhaust calculated from normal temperature.		British thermal units available in the tanks assuming an average efficiency of 80 %.	Equivalent coal (calorific value of 13 860 British thermal units per lb.)
685 — N. 5.	5 × 3 032 730	15 163 650		
680 — N. 1.	1 × 2 589 038	2 589 038		
625 — N. 2.	2 × 2 052 290	4 104 580		
875 — N. 2.	2 × 1 375 024	2 750 048		
835 — N. 4.	4 × 1 188 518	4 754 072		
735 — N. 6.	6 × 2 934 951	17 609 706		
Total. . .		46 971 094	37 576 864	About . . . . . 3 115 lb.

It will be observed that the average efficiency of blowing off has been taken at 80 %, when this same efficiency owing to the continuous working of the plant, and arranging things so as to avoid an excessive loss of heat, reaches 85 %, the effective utilisable calories in the tanks ought to reach 38 986 600 British thermal units, corresponding to 1 500 kgr. (3 307 lb.) of coal which it should be possible to save daily.

The outstanding feature of these figures is the actual benefit gained from the installation and the advantages which one gets by the recuperation of the heat contained in the water blown off and the exhaust steam from the locomotives.

[621 .135.2, 621 .135.3 & 621 .135.4]

QUESTION VI

BOGIES (TRUCKS), AXLES AND SPRINGS OF LOCOMOTIVES

Best arrangement of the bogies, axles and springs of locomotives, especially of locomotives for high speeds, with long wheelbases, so as to facilitate running round curves and to ensure the proper stability of the engines.

Preliminary documents.

1st report (Belgium, Denmark, Norway and Sweden), by Mr. E. Minsart. (See English edition of the *Bulletin* of December 1921, p. 2039, or separate issue [with red cover] No. 46.)

2nd report (all countries, except those using the English language, Belgium, Denmark, Sweden and Norway), by Mr. Bochet. (See English edition of the *Bulletin* of January 1922, p. 193, or separate issue [with red cover] No. 55.)

3rd report (Countries using the English language), by Mr. G. Hughes. (See English edition of the *Bulletin* of October 1921, p. 1589, or separate issue [with red cover] No. 38.)

Special reporter : Mr. G. Hughes. (See English edition of the *Bulletin* of April 1922, p. 658.)

SECTIONAL DISCUSSION

Meeting held on 19 April 1922 (morning).

Mr. G. GIBBS, IN THE CHAIR.

The President. — Mr. Hughes, special reporter, who was charged with summing up the different statements which have been made on this subject, will speak.

Mr. Hughes read the special report which he had prepared and which has been published in the April 1922 number of the *Bulletin*.

He showed three interesting photographs of a locomotive which had been suspended in order to determine its centre of gravity.

The President. — Have any members any remarks to make concerning Mr. Hughes's summary?

Mr. Bochet, *reporter*. (In French.) — I do not understand what Mr. Hughes has just said, but looking through the French translation of his report I find some statements which are very similar to those which I have put in my own report for the countries with which I have had to deal. It would appear from the information collected by Mr. Hughes and from that which I have myself received from the Latin countries, that similar rules are followed in the two groups of countries.

In both cases one finds two schools of thought, the essential points of which I have drawn attention to in my report, namely, the American school which aims at obtaining the greatest flexibility possible with the special object of facilitating the entering of a curve, and the school which I have called the Alsatian, because a well known example has been built by the « Société Alsacienne de constructions mécaniques », which aims on the other hand at giving the bogies a greater amount of restraint which is an advantage when running on a straight line or on a curve of constant curvature.

The supporters of the latter system recognise that the track is subjected to greater reactions than is the case with the American system, but they think that they obtain on the other hand a greater stability of the engine, and this is an advantage, especially from a point of view of the comfort of the footplate staff.

As is shown in Mr. Hughes' report, the first view is held extensively in America and in the United States in particular. The second on the other hand has more supporters in England and in the English Colonies.

As regards compensating levers connecting the springs, two similar schools of thought exist, as is also pointed out in Mr. Hughes' report.

One method is to connect the spring of the different wheels of the engine and to obtain, by means of compensating levers, a more uniform distribution of the load on the different wheels. It is also considered that this important result is obtained, namely, that the engines adapt themselves better to the little inequalities of the track, which they are bound to meet with when running.

On the other hand, the railways which do not employ compensating levers and which are even opposed to them on principle, consider that by dispensing with this device a greater simplicity of construction and a reduction in maintenance cost is obtained on the one hand, and on the other a greater stability is obtained as regards the minor oscillations of the engine.

In this connection a question arises, which as not yet been entirely solved, namely, the effect of compensating levers on the breakages of springs. Some railways consider that the use of compensating levers tends to increase the number of these breakages, which certainly is a serious matter.

This view would have to be accepted if it were supported by the results of tests which are wholly reliable and conclusive and by carefully drawn up statistics.

From first principles it appears that this result would be rather extraordinary, and one should from a theoretical point of view expect on the other hand to obtain a diminution in the number of spring breakages where compensating levers are employed.

In this connection I find in Mr. Hughes' report a very interesting point which had escaped me, that is, that where independent springs are used for each wheel, when the spring breaks, it is not such an important matter, as the adjacent wheels take the load of the defective wheel. On the other hand, where compensating levers are used, such a casualty, even if it rarely occurs, has much more serious consequences, since owing to the compensating levers the suspension of the whole of the locomotive on the side on which the breakage has occurred is affected.

Both of these methods therefore have advantages and disadvantages, and it does not appear to me that at present sufficiently conclusive arguments have been put forward in favour of either one or the other.

Our colleague, Mr. Minsart, who will shortly speak, has arrived at conclusions which are rather narrower and he will tell us himself on what experimental data and for what reasons he has been led to arrive at these conclusions.

Personally it appears to me that the question remains an open one. In the report which I have drawn up and which you have before you, I have endeavoured to show as concisely and as complete as possible the arguments put forward in favour of both theories, but I believe that it is difficult to come to any definite decision at the present time.

Such are the two principal questions which appear to me to present themselves from the study of the very full information which the different railway companies which I have consulted have been kind enough to send me. The other questions are only questions of detail from which I shall abstain from mentioning here, that is unless members wish me to do so.

Mr. Minsart, *reporter*. (In French.) — Gentlemen, the first question dealt with in the reports is that of bogies. Mr. Bochet has very clearly stated the differences which exist between the two systems of bogies which are in use.

On the railways which I have had to deal with, both types of bogie are employed, but the reports which I have received have not enabled me to arrive at a conclusion favourable to either one or the other system.

As regards the Belgian State Railways, locomotives with central support and gravity centreing have been in use for a long time and have proved satisfactory, but some express locomotives have recently been built in which it has appeared advisable to provide for the gravity centreing having an initial centreing force, that is to say, by triangular swing links. These engines are four cylinder compounds with a bogie and six coupled wheels of 5 ft. 10 7/8 in. diameter. They have proved quite satisfactory as regards stability.

In general, it is very difficult to say which is the best bogie in all cases. My personal opinion is that the most simple bogie is one with gravity centreing and an initial centreing force by triangular swing links.

As regards the points of support, one can choose between several methods. The central bearing may be used, or on the other hand, where gravity centreing by means of triangular swing links are used, the points of support may be at the sides.

If the side bearing allows the frame of the bogie to have a certain amount of longitudinal oscillation relative to the main frame, the springing need not have any special features, that is to say, the springs of the two axles of the bogie may be independent, but if a plain central bearing or plain side bearings are used, it may be as well to connect the springs so as to divide equally the load over the two axles. I have mentioned in my report that one railway, however, uses this system without any connection between the springs.

There is also the same difference of

opinion as regards the springs for the coupled axles. Some railways consider it advisable to use compensating levers, while others consider that the expense entailed by the use of these levers is not justified by the advantages gained from this system.

Mr. Bochet dealt with the question of the length of the radial arm, of the Bissel truck. It is stated, I believe, that the French Est Company attaches great importance to the length of the radial arm so that the axle may always be normal to the curve.

Dealing with this point, if one looks at Mr. Hughes' report it will be seen that he has mentioned two formulæ, that given by Mr. Bochet and that by Baldry. These two formulæ appear to be very different; in practice, however, they are not as different as one might imagine.

Mr. Bochet. (In French.) — They are exactly the same, it is only the notation that is different.

Mr. Minsart. (In French.) — They are the same formulæ, except that Baldry's formula gives the radius of curvature for radial boxes, while that given by Mr. Bochet gives the length of the radial arm. I think that is the point.

Mr. Bochet. (In French.) — It is the same thing. The radius of curvature and the length of the radial arm both fulfil the same purpose.

Mr. Minsart. (In French.) — With this difference, as Mr. Hughes points out, that Baldry's formula gives the hypotenuse of a right angle triangle, whereas your formula gives the perpendicular.

As regards the balance of the moving parts, distinction is made between rotating masses and reciprocating masses. Everyone is in agreement as regards rotating masses; they are balanced directly and totally in the same pair of wheels as in which they occur. As regards the reciprocating masses, practice differs considerably between different railways, and it is very difficult to draw up any rules. One may, however, make a recommendation on this point; I would say that one ought in every case to consider the variation in the load of the wheels on the rails.

Some rules adopted for balancing reciprocating masses simply give a percentage of these masses which have to be balanced. Such a rule as this may be satisfactory, but it seems, however, that one ought to consider (if it is not specified in the rule) the variation in wheel load which will be obtained in applying this rule.

As regards balancing of reciprocating masses, I believe that the Midi Company endeavour to balance the largest possible proportion, not from the point of view of avoiding nosing action, but simply in order to avoid variations in the drawbar pull.

On the Belgian State we have no experience which leads us to take special measures to avoid this effect; though I may mention that one sometimes experiences oscillation between the locomotive and tender which appear to be due to this irregular drawbar pull.

However, investigations which have been made have shown that these oscillations are produced, because, at certain instants, the tender, which is coupled close up to the engine, comes away from the same by reason of accelerations which are alternately positive and negative, but at times when the acceleration is such that the drawbar spring is not sufficiently strong to preserve contact. The remedy is very simple, all that is required is to provide sufficiently strong drawbar springs and then this undesirable effect will disappear.

These, Gentlemen, are the special remarks which I have to make on the question before us.

Mr. Gresley, Great Northern Railway, Great Britain. — The Great Northern Railway use swing link bogies having suspension links, but have discontinued the use of flat centre bearings on these bogies. Spherical centre bearings are used. Oscillation is bound to result if flat centre bearings are used on swing link bogies. Bissel trucks are used on many of the modern engines. These trucks have a double set of suspension links, one set being mounted on the truck and the other on the engines frame. The advantage of this arrangement being that when an engine enters a curve the weight on each wheel remains constant and there is therefore no tendency to derailment which sometimes occurs in the ordinary bissel with single suspension links.

I have used chrome-nickel steel for connecting and coupling rods having a tensile strength of 50 tons per square inch with an elongation of 18 % on 2 inches, and have been able in consequence to reduce the weight of the rods by one third. The same steel is also used for pistons and hollow piston rods. 60 % of the reciprocating weights are balanced. After the counter weights have been carefully calculated the wheels are put in a balancing machine and rotated up to 80 miles an hour, corrections in the counter weights being made until the wheels run absolutely without vibration.

I claim that by the use of alloy steel for the reciprocating parts and careful balancing, a great reduction in the wear and tear of both track and of the locomotive will result.

The President. — Can any other delegates supply information on this question?

Mr. Bochet. (In French.) — Gentlemen, there is a point to which I think I should draw your special attention. Mr. Minsart has expressed a wish that the rule should be so arranged as to give the best proportion of reciprocating weights which have to be balanced. I do not think we can make any hard and fast rule on this subject. As you know, the balancing of reciprocating masses can only be realised in practice by the addition of revolving balance weights, and these, owing to the fact that they are rotating, in addition to producing a horizontal balancing effect, also produce undesirable vertical effects which cannot be avoided.

These considerations have led all the railways to do as we do in France, to make a compromise between the advantages and disadvantages. If one only balances a small portion of the reciprocating masses, the result is unsteady running. If too great a proportion is balanced, vertical forces are set up which result in hammer blows on the track. One must choose between these two evils and be content to accept the one in order to avoid the other, and the choice which is to be made is largely a matter of opinion. Some attach greater importance to the advantages obtained by one method while others prefer the other solution, and it is very difficult to draw up a hard and fast rule.

It may, however, be recognised that the stronger and firmer the track the greater the reactions one may be allowed to subject it to and consequently the more complete may be the horizontal balance of the reciprocating masses.

I have said on page 154 of my report (¹) many railways fix the proportion to be balanced so that the reactions on the track do not exceed a certain proportion of the total weight. This proportion is in many cases 15 %. It is considered that the variation in the wheel load resulting from the centrifugal forces of the balance weights should not, as far as possible, exceed 15 % of the static load.

The other rule which directly fixes a definite proportion of reciprocating masses to be balanced comes to very much the same thing in practice; thus a proportion of 30 % or one third which is adopted, gives practically the same result as a variation of 15 % in the static load. The two rules giving almost identical results. It will be sufficient I think to state this fact without trying to draw up any unnecessarily strict rule.

Another point on which it may be equally necessary to draw your attention is the question of the initial centreing force of the bogie. This has already been mentioned, but I think I should make a few observations on this subject. I have dealt with this in the conclusions of my report, and perhaps I have treated the question rather boldly and this is why I wish to make a few explanations.

As regards the question of the initial centreing force of bogies and bissel trucks, we may make almost the same remarks and develop similar considerations as I have previously mentioned when dealing with the method of suspension of bogies and the use of compensating levers. If there is no initial centreing force, as in the case of simple swing link bogies, the bogie has obviously great flexibility, and consequently this greatly facilitates the entry to a curve and the adoption of a bogie to any irregularities of the track. On the other hand, in view of this flexibility the engine is not so well guided. Consequently the advantages and disadvantages of either system have a greater or less importance in accordance with the nature of the track.

If this is very sinuous, with curves and reverse curves, it is important that the engine should adapt itself to these as easily as possible, and consequently it should be very flexible. It is advisable therefore that there should be hardly any initial centreing force, as is generally the case, except on one of the railways from which I have had information. If on the other hand the track is of strong construction, has a large proportion of straight line, and the curves are of large radius, as is the case of lines over which express trains are run, one can expect a greater resistance from the track and give less flexibility to the engine by reducing the movement of the bogie and providing an initial centreing force. This has the result of making the engine run much more steadily.

The initial centreing force is as a rule obtained by triangular swing links, of which Mr. Minsart has just spoken. There is, however, another system which has come to my notice which is specially used on the locomotives of the Italian State Railways. This system consists of employing swings links without initial centreing force and obtaining the centreing force by means of a special side spring.

On considering this arrangement, which appeared to me to be very ingenious in principle, I have been led to the idea which I have put in my conclusion, which is that it might be possible to devise an arrangement whereby the engine might from day to day be especially adapted for the line over which it was

---

(¹) *Vide* also *Bulletin of the International Railway Association*, January 1922, p. 222.

going to run. We may imagine for example a hand wheel, by rotating which one can adjust the initial deflection of the special lateral spring. It would obviously be necessary to have some extremely simple arrangement so that the driver or shed foreman might make this adjustment from day to day.

Supposing that an engine is fitted with this arrangement for adjusting the centreing spring on days when this locomotive has to run over a line which is chiefly straight or with curves of large radius and with a very strong track, a strong initial centreing force would be given by increasing the deflection of the spring. On the other hand, on days when the locomotive had to run over a branch line in mountainous country with many curves and a lighter track, by turning the wheel one would reduce the initial centreing force and render the bogie almost completely flexible.

This of course is merely an untried idea of mine, but if in applying it it would be possible to obtain a form of adjustment sufficiently simple for the staff concerned results might be worth while. I think therefore that I should mention this idea in my conclusion and draw the attention of technical engineers to it. (*Applause.*)

The President. — Will Sir Henry Fowler be good enough to let us know his views on the question?

Sir Henry Fowler, Midland Railway, England. — In the first place I wish to offer a few remarks on the subject of Mr. Hughes' report relative to the braking of bogies. Personally I prefer a steam brake to a compressed air brake, as the former occupies less space on the bogie.

On our railway the majority of the express passenger locomotives are fitted with bogie brakes, and these have given great satisfaction and no troubles have arisen from their use.

I should like to know if, on the Continental systems, standard methods exist for calculating the super-elevation at the entrances to curves. The calculation is easy for the case of a uniform curve, but the problem of calculating the super-elevation at the entrance of a curve is more difficult. Have experiments been made to ascertain whether a special transition curve at the entrance of a curve facilitates its entry by a locomotive?

I should also be glad to know if the members of the section could give any information with regard to the advantage said to arise from lubricating the flanges of locomotive tyres.

Mr. Bochet. (In French.) — As regards the question of braking bogie wheels, I have noticed in Mr. Hughes' report that this has been tried on certain English railways and has been given up because it has led to skidding the wheels. The principal duty of the bogie, which is to guide the engine, is not efficiently carried out, as the wheels when they skid have a tendency to mount the rail and cause an accident. This disadvantage is an extremely serious one, and should be avoided at all costs.

However, in order to avoid it, it is not absolutely necessary to dispense with bogie brakes. It is sufficient to reduce the brake power so that the wheels will always revolve. Even when keeping within this limit, which I would repeat it is important not to exceed, a considerable amount of braking effort can be obtained from the bogie which assists appreciably in stopping a train or in schecking it on gradients.

The load on the bogie being practically constant, is not subject to variations as are goods wagons or even the tender, and it is easy in applying a continuous brake to design this so as to obtain the above result, that is to say, so that the force between the brake block and the tyre is always less than the load on the wheel and thus cannot in any case prevent the wheels from rotating. However, under these conditions it may be that the supplementary brake effort will not be large enough to justify the first cost and maintenance cost of the brake apparatus. This I think is the whole matter.

The other point which has been raised is the question of super-elevation. I have given in table VI of my report the formulæ which are chiefly used on the railways of which I have been dealing. These formulæ are of two kinds. The denominator is always the radius of a curve, but the numerator is sometimes the speed of the train and sometimes the square of the speed. In the formulæ $\frac{av}{R}$ or $\frac{av^2}{R}$, the coefficient a is fixed so that the formula gives practically the same result for normal speeds; from 31 to 43.5 miles, for example, the two formulæ give practically the same result, but for very low speeds or very high speeds the results are naturally very different.

The different railways may be divided up as supporters of one or the other formula, as in the case of the question we have previously spoken about, and it is mainly a matter of personal opinion.

As regards the question of the entry to a curve and the way in which the super-elevation is gradually increased, it is obvious that this may be done progressively, the super-elevation commencing at zero and increasing to the maximum super-elevation. This always takes place partly on the straight and partly at the commencement of a curve. In order to make the radius of curvature more proportional to the super-elevation, which otherwise at certain points is not exactly suitable for the curve, the usual practice on the continent is to use a parabolic transition curve, the radius increasing progressively from infinity corresponding to zero super-elevation and gradually increasing to the radius of the curve. This allows the super-elevation to increase as an incline plane, corresponding exactly to the radius of the curve.

In order to obtain a still further refinement, certain railways use a cubical parabolic transition curve. This is a fairly complicated curve from a theoretical point of view, but one which if tables are prepared is as easy to apply as the others. Its use allows the super-elevation to increase, not as an incline plane, but as a parabola, a transition curve being thus obtained which is still more gradual and easy.

I have just said the formula is rather theoretical and complicated, but it is only necessary to draw up a table which the platelayers have to consult in order to know how many centimeters it should be from point to point; the platelayer has no calculations to make himself. (*Applause.*)

Mr. Maunsell, South Eastern & Chatham Railway, England. — On the South Eastern & Chatham Railway, with which I am connected, all the engines built for some years past have either four wheel bogies or two wheel « Bissel » trucks, both of which have gravity lateral control. The sliding surfaces are formed in three planes having an incline of 1 in 6, and arranged opposite in direction to each other so as to allow the load to gravitate downwards to the point of intersection of the planes. The slides are located in an oil tight chamber, and the sliding surfaces are immersed in a bath of oil. The fixed bottom slide is cast iron, the moveable top slide is cast steel, the latter being provided with a cup into which the centre ball pivot fits.

Our experience, after several years' observation of this arrangement, is that the wear of the sliding surfaces is negligible, and the cost of maintenance is, when compared with bogies of the side spring control or link suspension types, almost nil.

Mr. Bochet. (In French.) — This method is mentioned in my report as being in use on the Paris-Lyons-Mediterranean system.

Mr. Collett, Great Western Railway, England. — I think that the difficulty of fitting brakes to the bogie wheels has been quite satisfactorily overcome, and it has been the practice for a long time on the Great Western Railway to fit brakes to the bogies of all new engines and to all engines used for running fast trains. Many types of bogies have been used, especially those fitted with single and double suspension links, some inclined inwards and some outwards, but none of these swing link types have proved very satisfactory, and they have all been replaced by the horizontal sliding type, the central position being maintained by control springs. We have found the most satisfactory type of pony truck is that fitted with sliding inclined planes, and no control springs.

With regard to special steels we have for many years used nickel, chrome, vanadium, nickel-chrome, chrome-vanadium, etc., but little or no advantage was obtained from their use in the early trials, which was found to be due to the want of scientific heat treatment. To obtain the best results from these steels we have found that it is absolutely necessary that exact temperatures for the proper treatment for each particular variety and cast should be ascertained, and that special furnaces must be used for their treatment that are capable of maintaining without variation the exact temperature required, which can only be satisfactorily accomplished by the use of very accurate pyrometers.

Mr. Weiss, Swiss Federal Railways. (In French.) — As regards the fitting of brakes to bogies, the Swiss Federal Railways do this on all their recently built engines which run at speeds exceeding 46.6 miles per hour. The first bogies of this type were constructed in 1898 for the locomotives of the Gothard line. The brake system is very simple and has given complete satisfaction. The brake percentage is about 50 to 60 % of the weight on the rails, and we have never had any difficulties with this system. There is also an instruction from the Railway Department to apply brakes to the bogies of all locomotives which run at speeds higher than 46.6 miles per hour. We have more than 200 locomotives, both steam and electric, which have brakes on the bogies.

The question of braking bogies is an important matter for engines which have to run at high speeds. It is also desirable in the case of electric locomotives which do any amount of light running to brake the bogies, as without this it is not possible to stop except after a considerable distance.

The President. — The discussion will be continued at 3 o'clock this afternoon. I invite the reporters to meet here a little before the hour of the meeting to deliberate on the wording of a joint decision.

Meeting held on 19 April 1922 (afternoon).

Mr. G. GIBBS, IN THE CHAIR.

The President. — We are going to continue the discussion of question VI.

I have received from the *American Locomotive Company* a number of copies of an album describing the locomotives constructed by this company for the United States Railway Administration; also, a Year Book. These documents may be consulted by the delegates.

I beg the speakers who still desire to take part in the discussion to give one their names. The reporters have already deliberated, but, in order to word definite conclusions, they request that they may have a little more time. I propose therefore, to postpone till the beginning of to-morrow morning's meeting the presentation of the conclusions and a vote upon same. If no member wishes to speak on question VI, we may consider the discussion as closed.

Mr. Van Loenen Martinet, *vice-president*. (In French.) — I propose that the discussion of this question be closed.

— This proposal was adopted.

The President. — At the beginning of to-morrow morning's meeting the proposed conclusions drawn up by the reporters will be submitted to the section. We will then pass upon same.

Meeting held on 20 April 1922 (morning).

PRESIDENT, Mr. VAN LOENEN MARTINET, VICE-PRESIDENT.

The President. (In French.) — I have to open the meeting while waiting for our president, Mr. Gibbs.

We have in the first place to discuss the information drawn up on question VI. The reporters were instructed yesterday to draw up and lay before us the proposed resolutions. I call upon Mr. Bochet to kindly read us these proposed resolutions.

Mr. Bochet, *reporter*. (In French.) — Gentlemen, the text which I am going to read you somewhat different to that which has been printed in the yellow paper. We have thought it better to express the results of the discussion which took place yesterday morning in the form of the following final summary :

Final summary.

« Notwithstanding the long wheel bases of large powerful modern locomotives it is generally possible, under normal conditions, to construct locomotives capable of moving through curves of small radius without making articulated frames.

« The means generally used to facilitate the passage round the curves are, for the front axles, bogies or bissels trucks, for the rear axles, bogies or bissels or axles with side play.

« It may be said that the bogie has mainly become the necessary accessory of all locomotives which are intended to run at high speeds with heavy trains.

« When the rear axle is a coupled axle, sometimes side play is given, but generally the tendency is not to give it side play, but to thin the tyres of the intermediate axles.

« Bissel bogies are not used sufficiently to enable a conclusion to be arrived at. The construction of bissel bogies might be improved by simplification, which appears possible in certain cases. The length of the radial arm should be calculated in such a manner that the axles remain normal to the track, and the same applies to the radius of the radial axle boxes which are sometimes used.

« The method of supporting the weight of the locomotive on the bogie or bissel is either central or lateral, and the system of centreing by springs or gravity with or without initial centreing force. Opinions differ regarding which is the best method, but no definite statement can be made. It appears that the devices which give the front axles lateral freedom about their central position are to be recommended in the case of light track with many curves.

« Generally it is not the practice to give the front bogie and at the same time the rear carrying axle great freedom: For the suspension of the drivers and coupled wheels, laminated springs are in general use, and perhaps are the best, as the friction between the plates has a damping action which reduces the amplitude and duration of the vibrations and oscillations.

« With regard to compensating levers, no new facts have emerged which would alter the conclusions arrived at in 1900.

« In calculating the weights which are intended to balance the reciprocating parts, it is essential to ensure that the total load including the dynamic increment is well within the carrying capacity of the track from the point of view of maintenance. »

The President. (In French.) — Gentlemen, I should in the first place thank the reporters for the trouble which they have kindly taken in drafting this final summary. This is rather long, owing to the importance of the subject. It does not seem to me desirable to open a new discussion upon it, and I propose that it be at once adopted.

If there is no opposition I will declare its adoption. It will be sent to the Office of the Congress to be submitted to the general meeting.

— The final summary drafted by the reporters was adopted.

DISCUSSION AT THE GENERAL MEETING

Meeting held on 26 April 1922 (afternoon).

Mr. R. DE CORNE, HONORARY VICE-PRESIDENT, IN THE CHAIR.
GENERAL SECRETARIES : Mr. J. VERDEYEN; Mr. E. FRANZA; Sir HENRY FOWLER.
ASSISTANT GENERAL SECRETARY : Mr. N. GIOVENE.

Sir Henry Fowler, *general secretary*, read the

Report of the 2nd section.

(See *Daily Journal of the session*, Nos. 4-5, p. 5.)

« Mr. HUGHES (*special reporter*) gave a summary of the three reports which had been submitted to the Congress on this question, and briefly called the attention of the section to the different types of bogies, the methods of suspension and position of the springs.

« At the end of his summary he showed three interesting photographs of a 60 t. locomotive which had been suspended for the experimental determination of the position of the centre of gravity. The calculated height of this was 4 ft. 10 in. and the height found experimentally was 4 ft. 11 7/8 in.

« Mr. BOCHET (*reporter*) pointed out how difficult it was to put forward definite conclusions. It appeared to him that they were concerned with two types of bogies, the « American » and the « French » which Mr. Bochet called the « Alsatian » owing to it having first been brought out by the « Société Alsacienne de constructions mécaniques ». The Americans gave the greatest possible flexibility to their bogies in order to facilitate the entrance to curves. The French on the other hand aimed at obtaining a very steady engine during running both on curves and on the straight. They give their bogies a more rigid bearing and require a greater variation of the road to cause oscillation.

« With regard to the suspension of the locomotive proper, he pointed out the differences between separate springs for each wheel and the use of compensating levers joining up to the springs. In the latter case one can always depend upon an equal distribution of the weight between the axles by means of the compensating levers, whilst in the former, the engine is steadier and more easily repaired.

« With regard to the case of the breakdown of a spring, he agrees with Mr. Hughes that the use of independent springs is the less dangerous since the failure remains local.

« Mr. MINSART (*reporter*) stated that on the Belgian State Railways they used bogies with a central spherical bearing on a plate suspended by triangular links. In his opinion this type was preferable, it had given every satisfaction from the point of view of steadiness, especially on four cylinder compound locomotives with six wheels coupled and with a bogie in front, as had recently been put in service on the Belgian State Railways.

« With regard to the use of compensating levers, Mr. Minsart stated that they had never observed any inconvenience from their use on the Belgian State Railways; they were convenient in overcoming the difficulties of proportioning the load between the springs.

« Mr. Minsart also said that the formula given by Mr. Hughes for the calculation of the length of the tail piece of the bissel truck was the same as that given by Mr. Bochet. If one in the first place determines the curvature which should be given to the radial axle boxes, this gives the distance of the centre from the axle.

« Mr. **Gresley** (*Great Northern Railway*) said that on his railroad he employed bogies with suspension links, but he had discontinued the use of the central flat bearing and now used spherical bearings.

« He also used bissel trucks with a double set of links giving an equal distribution of weight on the two wheels.

« With regard to special steels, he said that he used chrome nickel steel (tensile strength 50 t. per square inch with 18 % elongation) for connecting and coupling rods, and was able to reduce their weight by one third. With the same object he used hollow piston rods.

« With regard to the balance of the reciprocating parts, he allowed for 60 % of the weight of these and the running of the locomotive is very steady up to 80 miles per hour, and had resulted in much less wear of the tyres and rails.

« Mr. **Bochet** thought that it is a difficult matter to establish absolute rules for the proportion of the weight of the reciprocating parts to be balanced. One in practice is forced to try and « strike a happy mean » : if the percentage is too low excessive horizontal disturbances result, whilst if on the other hand the percentage is too high there is the risk that the vertical disturbances set up may result in hammer blows on the rail. In fact the proportion has to be left to the discretion of the designers. The percentage taken varies not only with the country, but from one company to another in the same country. The practice of the Italian State Railway has been to adopt a proportion of 15 % and this leads to balancing 30 % of the reciprocating parts.

« With regard to the question of the initial centreing effect for bogies Mr. Bochet stated that the absence of this increased the ease of movement of the bogie. Such is the case when links and rods are employed, but the guidance of the bogie is then less correct.

« With initial centreing effect the running is steadier, naturally, both on the straight and on curves The ease of movement of the bogie is particularly necessary on sinuous roads. In the case of main lines with long straight runs and with easy curves it is desirable to allow the bogie less freedom.

« The Italian State Railway use two methods of centreing, namely, by links and by springs, in order to obtain steadier running.

« In the case where initial centreing is obtained by means of springs, one ought to have a definite rule as to the value of the centreing force. Mr. Bochet suggested the idea of making this force vary, by means of a device which has not yet been put into practice.

« Sir Henry **Fowler** (*Midland Railway*) stated that on his railway many locomotives are fitted with bogie brakes which acted satisfactorily. He asked if the delegates of other countries could give any information as to the super-elevation of the rail on entering a curve and also on the subject of the thinning of the flanges of the middle wheel tyres.

« He also asked as to the effect on the wear of tyres when lubrication had been applied to the flanges.

« Mr. BOCHET thought that the braking of bogies did not cause any danger if the percentage of the weight braked was limited, this would also prevent the possibility of any grave accident which might occur if the bogie wheels skidded and mounted the rails. He would like to know if under these conditions the braking of the bogie wheels was still of interest to the delegates and whether the actual advantages in working made up for the extra expense entailed. This was the point which really settled the question.

« He called attention to the fact that he had given in table VI of his report (column 27) various formulæ used for calculating super-elevation. In order that a curve may be entered easily, the super-elevation should gradually increase from *o* on the tangent to the full value given in table VI. This joining up ought to follow a law of the second degree (transition curve) or even of the third degree without causing any practical trouble. The essential point is that the deviation in direction should lead away as gradually as possible.

« Mr. MAUNSELL (*South Eastern & Chatham Railway*) said that on his railway they had had in service during the last six years bogies with moving links with centreing by means of inclined planes, and he was quite satisfied with these.

« Mr. COLLETT (*Great Western Railway*) agreed that it was desirable to brake the bogie wheels. On the railway he was connected with the results with swing link suspension had not been successful, they had also tried simple double suspension with link inclined each way, but had found it better practice to use horizontal slides.

« With regard to special steels, the Great Western had used chrome steels, vanadium steels and nickel chrome steels, but these were not successful without being heat treated at an absolutely definite temperature. Now they were provided with furnaces fitted with pyrometers and obtained material in a perfectly correct state and did not experience any trouble.

« Mr. WEISS (*Swiss Federal Railways*) said that in Switzerland they had about 200 locomotives both steam and electric which were fitted with bogie brakes. This practice commenced in Switzerland in 1898 and it is now actually required that the bogie wheels be braked of engines the speed of which exceeded 46 1/2 miles per hour. The amount of the weight on the rails braked is fixed at from 50 to 60 %. It is judged necessary to take these steps because the locomotives are sometimes required to run light.

« No one else wishing to take part in the discussion on this question, it was closed by the President.

« THE PRESIDENT proposed that the summary which had been drafted by the three reporters be read, and this was done in French, English and Italian by Messrs. Bochet, Hughes and Parodi (Paris-Orleans Railway).

« THE PRESIDENT thanked these gentlemen for the trouble they had taken in the matter, and proposed that this summary should be approved without discussion. This was agreed to and the following summary was referred to the General meeting. »

The President. — This is the

Final summary.

« Notwithstanding the long wheel « bases of large powerful modern loco« motives it is generally possible, under « normal conditions, to construct locomo« tives capable of moving through curves « of small radius without making articul« ated frames.

« The means generally used to facilitate « the passage round the curves are, for « the front axles, bogies or bissels trucks, « for the rear axles, bogies or bissels or « axles with side play.

« It may be said that the bogie has « mainly become the necessary accessory « of all locomotives which are intended « to run at high speeds with heavy trains.

« When the rear axle is a coupled axle, « sometimes side play is given, but ge« nerally the tendency is not to give it « side play, but to thin the tyres of the « intermediate axles.

« Bissel bogies are not used sufficiently « to enable a conclusion to be arrived at. « The construction of bissel bogies might « be improved by simplification, which « appears possible in certain cases. The « length of the radial arm should be cal« culated in such a manner that the axles « remain normal to the track, and the « same applies to the radius of the radial « axle boxes which are sometimes used.

« The method of supporting the weight, « of the locomotive on the bogie or bissel « is either central or lateral, and the « system of centreing by springs or gra« vity with or without initial centreing « force. Opinions differ regarding which « is the best method, but no definite sta« tement can be made. It appears that « the devices which give the front axles « lateral freedom about their central po« sition are to be recommended in the « case of light track with many curves.

« Generally it is not the practice to « give the front bogie and at the same « time the rear carrying axle great free« dom : For the suspension of the driv« ers and coupled wheels, laminated « springs are in general use, and perhaps « are the best, as the friction between the « plates has a damping action which re« duces the amplitude and duration of « the vibrations and oscillations.

« With regard to compensating levers, « no new facts have emerged which would « alter the conclusions arrived at in 1900.

« In calculating the weights which are « intended to balance the reciprocating « parts, it is essential to ensure that the « total load including the dynamic incre« ment is well within the carrying capa« city of the track from the point of view « of maintenance. »

— The general meeting ratified this summary.

[625 .23 (01]

QUESTION VII

PASSENGER CARRIAGES

Improvements to be made in the design of carriages and rules to be observed in the make-up of trains, so as to increase the safety and comfort of passengers.

Preliminary documents.

1st report (America), by Mr. B. F. Bush. (See English edition of the *Bulletin* of September-October 1914, p. 839, or separate issue [with red cover] No. 3.)

2nd report (Spain, Portugal and countries using the same language), by Mr. F. de Vargas. (See English edition of the *Bulletin* of May 1921, p. 461, or separate issue [with red cover] No. 15.)

3rd report (America), by Mr. W. J. Tollerton. (See English edition of the *Bulletin* of October 1921, p. 1399, or separate issue [with red cover] No. 33.)

4th report (all countries except Spain, Portugal and countries using the same language, Great Britain and America), by Mr. E. Biard. (See English edition of the *Bulletin* of September 1921, p. 1205, or separate issue [with red cover] No. 30.)

5th report (Great Britain, India, Australasia and South Africa), by Mr. R. W. Reid (See English edition of the *Bulletin* of November 1921, p. 1859, or separate issue [with red cover] No. 43.)

Special reporter : Mr. E. Biard. (See English edition of the *Bulletin* of April 1922, p. 662.)

SECTIONAL DISCUSSION

Meeting held on 25 April 1922 (morning)

Mr. G. GIBBS, IN THE CHAIR.

The President. — We now come to the discussion of question VII : « Passenger carriages. »

I call upon Mr. Biard, the special reporter.

Mr. Biard. (In French.) — I have to apologise for having drawn up my summary in a special manner owing to the fact that the subject is so comprehensive; it deals with a number of very difficult questions. I have dealt with them, however, as briefly as possible, but even then the summary consists of 38 paragraphs.

The President. — It would be very difficult for me to put before you thirty eight points. Our reporter will perhaps be good enough to say which are the more important points which might be the subjects of a general discussion and allow of the consideration of the summary as a whole.

Mr. Biard. (In French.) — The thirty eight points are simple summaries of the improvements made to carriages.

The improvements dealing with safety are given in No. 3. Safety in travel depends on the condition of running, the effects produced in case of accident, and comfort given to individual passengers. Safety is the object of all investigations into improvement.

What means have been employed to obtain these improvements are set out in No. 4. It will be seen that they consist of the general arrangement of the carriages, the different parts used in their construction and the various accessories.

In fact, the first four points of the summary ought to be excluded from the general discussion, because everybody is of one mind on this subject.

The President. — Are not the principal conclusions which detach themselves from paragraph 4 included in the question of coaches entirely built of steel?

Mr. Biard. (In French.) — From the replies sent in by the administrations consulted, the different reporters have gathered together all the information which they contain.

Many of the administrations, with the exception of those in America, have not been able so far to use steel carriages. Consequently I have been obliged to deal with arrangements other than those of electric vehicles. The question of the construction of metal carriages it seems to me ought to be considered under paragraph C.

In order to put the question of the discussion in order, I propose, Mr. President, that we follow the order of the paragraphs, so that each point may be considered in turn. If we deal first of all with the question of steel carriages, we shall be liable perhaps to neglect giving consideration to other special points which should also receive attention, such as, the safety and comfort of the passengers.

The President. — I must again call attention of the meeting to the importance of confining our discussion to the *general features* of the question, if we are to arrive at conclusions which will be of value.

If you will allow me, I shall speak briefly on the general subject of steel construction for passenger carriages.

I was a pioneer in this type of carriage in America, having personally designed the first steel cars used, as the result of my study of the question of safety in the operation of New York City subways (Interborough Rapid Transit Railway).

The conditions imposed were unusual as regards the carrying capacity and frequency of trains operated in the tunnels, and the fact that electrical apparatus was carried on each car and live third rail conductors laid along the sides of the tracks. Thus, if inflammable material was present in the car construction there was danger of a disarrangement leading to the setting of a fire; the consequences of this in starting a panic — or worse — were too serious to contemplate.

A similar problem arose about the same time, fourteen years ago; the Pennsylvania Company proposed establishing a very large terminal station in New York City, reached by long tunnels under the rivers on either side of the City. The whole project was predicated upon hauling trains by electricity, and the company believed it essential for safety to exclude wood in the construction of the cars. Therefore, the radical decision was made to proceed at once with design and construction of all steel trains equipment which would use the New York Terminal.

The New York Central Railroad Company had much the same problem to solve at its new terminal in the city.

The result of all this has been to establish the steel passenger carriage as standard throughout the Country and, as a general statement, it is correct to say that wooden carriages are no longer built for trunk-line railways in America.

Mr. Biard. (In French.) — I appreciate fully the importance of the questiou of metal carriages, but I wish to urge that we do not forget in connection with this the other points dealing with the method of construction of the carriages.

The material used is only one of the points we have to consider when dealing with methods of construction, and as I understand it, it is paragraph C which deals specially with this point; is this, however, any reason for passing by all discussions on sections A and B? I do not know if my colleagues have found anything to interest them in the information which has been sent in by the various reporters with regard to the general arrangement of the carriages and the layout of the interior of the bodies. It seems to me, however, that these questions come under the programme which has been laid down to the Congress : « Improvements taking place to passenger vehicles » (in all the publications, it seems to me). I do not object to first dealing with section C, but it appears to me that the other points should not be passed by without remark. Will it not therefore be preferable to keep the order which has been followed by all the reporters, without exception. This sequence is precisely that which was adopted in the questionnaire by common consent, as much for the convenience of the administrations of the various countries as for the preparation of their reports.

Mr. Van Loenen Martinet, *vice-president.* (In French.) — I believe that we are talking at cross purposes. The idea in the mind of the President, it seems to me, is that if we attempt to deal with all the questions of detail mentioned in the thirty-eight paragraphs of Mr. Biard's summary, we shall never get to any general summary in the time at our disposal. The President, then, wishes to see discussed first of all several general points which are capable of being condensed in the summary, such as the use of steel, lighting and heating. It appears to me that these three main divisions are three on which we should draw up summaries for the Permanent Commission. If we find we still have time at our disposal, we ought to devote it to the consideration of other questions.

Mr. Biard. (In French.) — I fall in with the desire of the President, and propose that we first of all deal with question C. I must, however, remark that the question of steel carriages is almost one which concerns America only, and that all those points which concern other countries ought not to be put on one side.

The President. — We therefore come to the examination of the question of steel carriages. It is for Mr. Reid to speak.

Mr. Reid, *reporter.* — I would draw your attention to the limitations which are imposed on the rolling stock designer in Europe in regard to the weight and length of passenger coaches, by reason of the restrictions of the load gauge and weight allowable per axle on the locomotives, which means, in effect, that on many lines an increase in the weight of trains beyond the present limits would necessitate double heading.

In speaking of steel coaches I think we should differentiate between what may be called the American design, which is excessively heavy, and the metal — or part metal — coach employed on European lines in which, whilst closely following the design of wooden carriages, steel panelling and framing has been substituted for the portions formerly made of timber for protection against fire, and that without seriously increasing the weight or shock resisting properties of the vehicle.

The American method of construction differs considerably from the European one. In America the coach body and underframe are in one, and the vehicle is designed with a view to making it collision-proof. The absence of side doors in the American cars enables a much stronger vehicle being built.

In England, on the contrary, the body — usually of wooden construction — rests on the underframe, and this latter has not only to resist the tractive effort, but also to carry the weight of the body, and the passengers. Generally speaking European coaches cannot be described as collision-proof.

It is improbable that we shall see the American type of coach adopted in Europe, because the tendency is all towards reducing the dead weight hauled per passenger.

It would, I think, be interesting if, in connection with the study of safety to be obtained by the installation of electric lighting and steam heating (in place of gas lighting and coke heating), more attention were directed towards improvements in signalling installations, rather than by increasing the cost of building passenger carrying vehicles, and, incidentally, the weight of same.

Mr. Tollerton, *reporter*. — I have been very much interested in the discussion and by the information given by Mr. Reid. I call attention to the great difference which exists between journeys in America and in Europe. I am convinced that the type of coach with lateral entrances, like those in England, is quite sufficient for short distances and for the European standard of comfort, but, in America, where the journeys are extremely long, where they last, for instance, five or six days as for the journey Quebec to Vancouver, travellers demand much greater comfort and the companies have not hesitated to increase the weight of the carriages per axle in order to satisfy these requirements.

I would also draw attention to a point which has been neglected, up to now in the discussion : the cost of maintenance of carriages.

Steel carriages last an extremely long time and the work of maintenance required for them is a very small matter. On the contrary it often happens that one is obliged to entirely renew a part of the body of wooden carriages of European construction.

I therefore insist on this point that the maintenance of steel coaches is much less expensive than that of wooden ones.

Mr. Van Schouwenburg, Dutch Indies Railway. — I will draw attention to another point which explains the considerable difference in weight between American and European coaches : this is the use of the central coupling. The tractive efforts and the shock being borne by this central coupling, it is comprehensible that the weight of the frame must be considerably greater when using central coupling.

For the rest, I refer to the reports of Messrs. Reid and Tollerton.

Mr. Van Loenen Martinet. (In French.) — Whilst the subject is not one with which I am familiar, I may say that in Holland it is the intention to employ steel carriages for two reasons. In the first place we think that we shall, for the same weight, be able to construct a stronger carriage in steel than in wood. Beyond this, we believe that in the long run the maintenance of steel carriages will be lower than that of wooden ones.

The President. — In reply to Mr. Reid's request for information, I should like to make a remark on the subject of the weight of passenger coaches in America, reserving the right to correct my figures in the final proof of the minutes.

In my opinion, it must not be admitted *a priori* that the steel coach is essentially much heavier than the wooden one. To my thinking, the excess of weight for steel reduces itself to about 10 %, when comparing two coaches of the same dimensions, the same carrying capacity and having the same equipment features; and for this excess weight we obtain a steel structure which is stronger than the wooden one in its resistance to shock and the destructive effects of derailment, etc. Without doubt, the weight of passenger cars has increased recently in the United States; but this must not be imputed entirely to the more general use of steel, but rather to the desire to obtain cars of the maximum strength and ones which contain numerous special features for the comfort of the passenger.

In the ordinary long distance coaches, comprising 88 seats, the weight per passenger is from 1 200 to 1 400 pounds. In the case of sleeping cars of the Pullman type, the weight per passenger is about 6 000 when fully loaded, but in actual service full loads are seldom carried and the dead weight will generally amount to at least 10 000 pounds per passenger.

In the suburban trains, especially in motor car electric trains, the weight is 700 lb. per passenger for trailers and 1 100 for the motor coaches.

Mr. Tollerton. — American practice extends over more than twenty years and actually 100 % of the passenger coaches constructed are of steel. This system was brought about by the desire to ensure the complete safety and comfort of travellers and to diminish as far as possible the cost of maintenance.

This statement shows the interest of the experiment made in the United States.

Mr. Reid. — I find in the figures quoted by the Chairman — figures which he has given as approximative — justification for what I said a few moments ago; that is to say the American type of construction is not applicable to Europe. At the most, in Europe, we might consider the use of steel panels, thus somewhat lightening the construction.

In support of this argument, I can give particulars in regard to England. For the suburban services the weight per passenger is 600 lb. for coaches of the latest model with a frame and wheels of steel, fitted with electric lighting and a wooden body. As regards ordinary corridor carriages the weight may reach 900 lb.

It may be possible to improve on these figures if, on account of its non-inflammability, steel panelling be adopted.

If in England, however, one were obliged to adopt the same principles and the same characteristics of solidity as exist in America in order to make them safe against accidents, then one would arrive at a weight of 1 400 lb. per passenger.

I would point out that the length of the coaches is approximately the same in England as America, *i. e.*, about 66 feet.

The President. — I desire to dissipate a confusion which may have arisen in the minds of certain members. If we were obliged to construct, in America, wooden coaches, answering to the same requirements, from the point of view of comfort and safety, the weight per passenger would be only slightly less than for steel cars.

Mr. Cooper, City & South London Railway. — I should like to give some particulars relating to the London Underground Railways.

On the lines generally called the « Tubes », excepting the first two, from the commencement steel carriages have been used.

No decision to use all steel is shown in the policy of the Metropolitan District Railway, which runs partly through tunnels under the City and partly in the open air. At the commencement of the electric working the carriages were built of fireproofed wood; for the recent rolling stock, dating back about a year, steel was used practically throughout, wood only being employed for a very few details. After a year's experience, results are not entirely satisfactory; these carriages are much more noisy than wooden ones, they are colder in Winter and generally there is an absence of comfort. It has been found difficult to give a good appearance to carriages constructed in this manner, unless some wood is used in the construction and interior fittings; it has been found also very costly to completely reject wood and it is probable that in future the District Railway will decide to construct the underframe of steel as well as the principal members, and to have a more liberal use of wood, in particular for the interior finish.

In conclusion I would say that I am of the opinion that the danger of fire from the presence of electric power may be overcome by other means than the exclusive use of steel.

The President. — In order to draw a conclusion from this exchange of views, could not the reporters meet and present a project of decisions concerning paragraphs 18 and 19 of Mr. Biard's report?

Mr. Biard. (In French.) — We are in agreement to follow that procedure.

The President. — This being the case, I propose to pass on to the examination of letter E, that is to say the one which deals with the different applications of heating, of lighting and of brakes, paragraphs 28 to 33 of Mr. Biard's special report. (*Assent.*)

Mr. Reid has the floor.

Mr. Reid. — I should be very glad to have a few particulars of the policy adopted by the French railways with respect to the general use of electric lighting of passenger carriages. Is it intended to employ self-contained equipment on each vehicle? or is one vehicle intended to supply the lighting on itself and another vehicle attached to it?

In my opinion, although electric lighting offers advantages over gas from a safety point of view, the small cost of equipment, maintenance, and satisfactory results obtained from the latter, are such as to prolong its existence.

Mr. Biard. (In French.) — To my knowledge, the French railways have used, up till a little time ago, gas lighting almost generally.

Lighting by incandescent gas, which

improved enormously owing to the use of inverted or cylindrical mantles, is general.

For several years past electric lighting has tended to take the place of gas lighting on several lines. Since the fire in the Batignolles tunnel in Paris, gas lighting has been condemned in France almost completely. The Railway Department has fixed a time by the end of which electric lighting should be substituted for gas.

I regret that I cannot give a more detailed account of the state of question which has only been actively in the front during the last two years. Perhaps one of my colleagues will be able to supply information.

I ought to add that where it has been used, particularly on my own company, gas lighting has given very satisfactory results. It is very easy to use and the expense entailed is moderate.

With regard to electricity, we have not very exact figures on the yearly expense, and I believe it is very difficult to get actual information on this point. The comparison, in fact, is a very difficult one to make.

Mr. Van Loenen Martinet. (In French.) — In Holland the lighting is generally by means of gas, but for ten years now we have commenced to use electric lighting, and it has been decided that all new stock shall be provided with it.

The arrangement generally adopted is that of a dynamo under the carriage and one battery.

With regard to the cost of maintenance, this is a very difficult thing to determine. One ought, however, to work out the figures. As far as we are concerned, the experience which we have had leads us to estimate that before the war the cost of electric lighting was nearly double that of gas. Since then, however, many improvements have taken place in electric lighting. Now a single battery system is used. The electric lamps are much more economical and we believe that at present there is not much difference between the cost of the two systems of lighting.

Mr. Tollerton. — The reasons which determined the general use of electric lighting for passenger cars in America seem to be different to those which appear as the result of the discussion.

The production of gas for lighting the cars, in the United States, was extremely costly. While Mr. Reid indicates the cost of production at 9 sh. per 1 000 cubic feet, the price in the United States would be nearly 5 dollars. The cost of electric lighting is incontestably less. Also, for the last ten years, not a single car provided with gas lighting has been built.

It must, on the other hand, be taken into consideration that electric lighting provides much more comfort and pleasure for the passengers than does gas lighting.

In conclusion, by reason of the improvements made to electric lighting plant, it may be estimated that, in the United States the cost of electric lighting is less by one-half than that of gas lighting.

Mr. Glover, Great Northern Railway, Ireland. — On the systems of the North of Ireland, there are actually 100 % of the vehicles which are fitted with electric lighting. It is not because these installations are economical from the point of view of first cost, quite the contrary, but the policy pursued has been inspired by the desire to give really bright lighting to passengers. The annual redemption of the electric plant reaches, in relation to the pre-war cost and to the actual cost of renewal, £20 per annum and per carriage. The total cost for interest, redemption and renewal reaches £37 per carriage. But these figures apply to the capital invested before the war and to the actual cost of renewal.

A battery generally does not resist for more than nine months and requires to be washed. So that the total life of a battery does not exceed more than eight or nine years.

Six hundred carriages of my system are now provided with electric lighting. For the superintendence of these plants, there are only eighteen men, the supervision of whom is easy.

A difficulty that is encountered is that of maintaining the battery sufficiently charged on short journeys, especially those of 10 miles with four of five stops. The necessary speed for charging the battery being 15 miles, it has been necessary, on certain lines, to establish, in the stations, auxiliary charging posts.

Col. Pringle, Ministry of Transport, England. — The official point of view in England is that electric lighting is the safest form of illumination for railway carriages, and is therefore to be preferred, especially for main line and express services. A number of accidents have occurred in recent years, the disastrous effects of which have been seriously aggravated by fires originating in burning gas jets. We shall therefore welcome the day when Railway Companies decide to replace all gas or oil lighting of railway carriages by electrical lighting.

Mr. Jacqmin, Ministry of Railways, Belgium. (In French.) — The use of electric lighting for the carriages of the Belgian State Railway has been greatly extended. The only system actually in use is that in which each individual carriage is fitted with a dynamo and one or two batteries.

The Belgian State Railway tried, before the war, a system of general lighting of the whole train from an electrical generating set placed on the boiler of the locomotive. This consisted of a small two-cylinder simple steam engine without governor and having full admission. This was direct coupled to a continuous current generator with independent and constant excitation obtained from three accumulators placed on the locomotive.

This set ran automatically at a speed proportionate to the electrical resistance of the train circuit. It supplied current of constant amperage, giving a voltage which varied with the number of vehicles to be lighted.

The train was lighted or the lighting shut off by the driver simply opening or closing a special steam valve between the boiler and lighting engine.

This system has been given up. It led to a high steam consumption and frequently to too high voltage at the lamps. It was also unsatisfactory in that difficulties arose in arranging for the constant lighting of the vehicles fitted, and the result was that it was not generally adopted. The latter difficulty was partly got over by fitting the vehicles with a system of lighting by gas in addition.

The President. — I will request the Committee of Reporters to be also good enough to examine the possibility of presenting some conclusions reflecting the statements uttered on the subject of paragraphs 29 and 30 of the special report of Mr. Biard. (*Assent.*)

We come to the examination of the question of heating of carriages.

The conclusion of the report is that steam heating emanating from the locomotive is coming more and more into general use.

Mr. Collins has the floor.

Mr. Collins, South African Railways

& Harbours. — I am extremely desirous of having some information on the subject of the method of heating employed in carriages drawn by electric locomotives.

Mr. Van Loenen Martinet. (In French.) — This question ought to be considered with that of electric traction. It is such a special point that we ought not to consider it now.

Mr. Barnet Lyon, Ministry of the « Waterstaat », Holland. (In French.) — I am in agreement with Mr. Van Loenen, but the question ought most decidedly to be considered. I call to mind that once I was travelling in the United States and found the Chicago-Milwaukee train was heated by means of a petroleum fired boiler. The fumes given out by this system of heating were a much greater nuisance than the soot and dirt from a steam locomotive.

I think that this question is of sufficient importance to be put down for the consideration of a future Congress.

The President. — It is a question of deciding how cars of electric trains can be heated : if they will be by steam or by some other process.

Mr. Glover. — According to the experiments that I have made, I consider as impossible the heating of carriages by a dynamo mounted on an axle. This system could only heat, at the outside, three compartments, that is to say a very small part of the necessary volume.

Mr. Van Loenen Martinet. (In French.) — I wish to propose that we do not vote any conclusions, because I consider that we ought not « to force an open door » and we ought not to present a resolution to the full meeting. Everything points to the fact that heating by steam from the locomotive is becoming more and more general. There are yet certain improvements to be made, and these are under investigation.

Mr. Biard. (In French.) — I would like to be allowed to remark that it is advisable sometimes to state just how matters stand. This is a point which has been proved in previous sessions.

May I also state, in addition, that in France there are railroads on which the whole of the trains were heated on the thermo-syphon system. It follows that general heating by steam is comparatively recent. Even today one could mention countries where steam heating is not universal. All that is necessary to convince one on this point is to turn to the proceedings of the last Congress. It would seem that the proper thing to do, in a Congress which meets periodically, is to record the fresh progress which has been made from session to session. The criticism which has just been raised by Mr. Van Loenen will allow one easily to follow the situation.

Mr. Van Loenen Martinet. (In French.) — I do not insist on my point.

The President. — I support Mr. Biard's way of looking at the matter. Doubtless, in America, properly speaking, there is now no other system of heating than that by steam; but, as in Europe, others are in use, it appears to me to be desirable to pronounce some decision on paragraphs 31-32. (*Marks of approval.*)

— The summary was adopted.

VARIOUS APPLIANCES.

Mr. Reid, *reporter.* — Has the section the intention of discussing the two categories of brakes?

The President. — I believe not. (*Assent.*)

Are there any objections to be raised to No. 33 of Mr. Biard's decisions? (*No, no!*)

— I declare this decision adopted.

INTERNAL ARRANGEMENT OF CARRIAGE BODIES. DETAILS OF CARRIAGE FITTINGS.

The President. — The discussion is open on Nos. 13 to 16 and 22 to 27.

Mr. Süss has the floor.

Mr. Süss, Madrid, Saragossa & Alicante Railway. (In French.) — I wish to speak on the question of the protection of individual passengers from criminal attack.

The several reports which have been presented do not deal with any new feature of this subject, in spite of the increase in the amount of trouble which has arisen in this respect in recent years and which has caused public opinion to be aroused very strongly on the matter.

It is impossible to avoid attack on sleeping passengers, but one should be able to perfect alarm signals so that they may be at once used when one appreciates that trouble is likely to occur.

The most usual type of signal consists of a handle fixed near the roof of the compartment, the pulling of which puts into action the continuous brakes and a slackening of the train follows, which leads the driver to stop the train completely.

It must be remembered that a passenger who is attacked or suddenly aroused is obliged to rise and lift his arm in order to work the alarm, and those who are attacking him can easily prevent this by threatening with a revolver. Even if the alarm signal has been pulled, the assailants are able, while the train is slowing down, to get off and escape, as was the case in an attack made on the Marseilles express recently.

In Spain for some years all the passenger trains are accompanied by two gendarmes, but even this, however, does not prevent attacks being made any more than do alarm signals which are also fitted.

Attacks particularly take place in first class compartments, which are more and more forming part of corridor carriages. It would be relatively easy to instal in the four corners of each compartment above the level of the arm-rest, that is to say, close at hand to passengers either sitting or lying down, a push button which would ring loud bells in the corridors, thus calling the attention of the staff which usually accompany these trains and other passengers.

These signals would operate, as in the case of wagon lits, small discs which would be carried outside a particular compartment, and would not cause the inconvenience that the usual alarm signal does by stopping the train.

If a signal of this type had been in existence in certain cases, the outrages would not have occurred, and even if they had the criminals would have been arrested.

I ask, as a consequence of the above, that we add to the conclusion of paragraph D a note that the Congress should call the attention of the companies to the advantage of adding to the alarm signals already in use others more easily accessible and arranged so that the attention of the staff on the trains and the other passengers can be called without slowing down or stopping the train.

Mr. Duchatel, Eastern Railway of France. (In French.) — The suggestion made by Mr. Süss has already been looked into in France. If it is correct that lately there have been several criminal attacks, it does not seem to me that they are necessarily becoming general and that one must conclude that it is imperative to take fresh measures to provide against this danger.

The question of alarm signals has had consideration for a long time and been dealt with very thoroughly. If it is necessary that alarm signals be placed so that they can be used by passengers, it must be remembered that they may have the disadvantage of being arranged so that they may be used too readily. Children have a tendency on railways to play with everything that comes within their reach. Alarm signals naturally excite their curiosity, and after a considerable experience one has come to the conclusion that these must be placed at a height so as to make it impossible for children to touch them easily, but not so high as to prevent passengers reaching them.

I believe that the arrangements adopted today are quite sufficient, and it is not desirable to go much further. If one fixes bells of the type indicated by Mr. Süss, it is to be feared that the inconsiderate use of them will quickly irritate passengers and that they will resort to means, easy to imagine, of preventing them working properly. On the other hand, if a criminal is contemplating making an attack on a person, will he not begin by putting the bell out of action? As a result, in France, we believe in leaving things as they are, and I propose that nothing be added to the summary put forward by Mr. Biard.

Col. Pringle. — In England, we consider that the decision proposed by Mr. Biard is quite sufficient. I do not therefore see the necessity of the addition proposed by Mr. Süss.

Mr. Süss. (In French.) — In spite of the objections which have been raised to my suggestions, I believe that they ought to be put forward. There has arisen in fact such a situation in France, following the very serious attacks which have occured in trains and which ought to be avoided, that I feel strongly that the Congress ought not to pass by a suggestion that the present system should be modified. I do not wish to suggest that the system I proposed is perfect or that it is the best which can be devised. It is the principle on which I lay stress, and I propose that the Congress express the view that the railway administrations should take up the matter so that it may be arranged that the alarm signals in use may be more accessible for passengers and so render attacks more difficult.

The President. — It is nearly midday. I propose to adjourn the meeting. (*Assent.*)

This afternoon we will examine the questions figuring under paragraphs A and B, that is to say the use of bogies or of ordinary axles for passenger coaches and the details of interior arrangements.

I hope that we shall be made cognizant of the decisions of the reporters on paragraphs 19, 29, 30, 31, 32 and 33.

Meeting held on 25 April 1922 (afternoon).

Mr. G. GIBBS, IN THE CHAIR.

The President. — Mr. Biard has the floor for the purpose of reading the decisions proposed by the Committee of reporters.

Mr. Biard. (In French.) — The following is the summary on paragraphs 18 and 19 relating to metal carriages :

« 5° The use of all metal or nearly all metal carriages has developed rapidly in North America. This method of construction is now generally adopted there and is considered to reduce to a minimum the risks attendant on derailments, collisions and fire.

« In Europe metal construction has not been applied to any appreciable extent, except in the case of electrified lines. On certain lines, however, steel construction is being considered with a view of reducing fire risk; it is not intended, however, to approach the weights of the American coaches which have been partly incurred owing to additional comfort provided for passengers. »

— Adopted.

Mr. Biard. (In French.) — This is the summary on paragraphs 29 and 30 : Lighting by gas and by electricity.

« 8° *Lighting.* — Notwithstanding the safety devices introduced, gas is now, in some countries, considered to be dangerous and to be liable, if not to cause, at least to increase fire following on collision. Electricity, particularly for this reason, tends to replace gas completely. »

— Adopted.

Mr. Biard. (In French.) — The summary relating to heating of carriages is as follows :

« 9° *Heating.* — The method of heating by steam from the locomotive is becoming more and more widespread. Recent improvements have been made with the object of better ensuring the flow of the steam to the last carriages of the longest trains, and to allow of the regulation of heat in the carriages or in the compartments. »

— Adopted.

Mr. Biard. (In French.) — This is the text of the summary relating to brakes :

« 10° *Brakes.* — The use of continuous quick acting brakes has been extended on nearly all the railway systems : trials have been carried out to increase the rapidity of action and effectiveness of the brakes on trains which run at very high speeds, and which have become of increased length and increased weight. »

— Adopted.

The President. — I propose we proceed with the examination of letters A and B and I beg Mr. Van Loenen to be good enough to replace me in the chair.

Mr. Van Loenen Martinet, *vice-president,* took the chair in place of the President.

PARAGRAPH A. — GENERAL ARRANGEMENT OF CARRIAGES. BOGIES.

Mr. Gresley. — I think I ought to give some additional information with regard to the arrangement of articulated coaches used on the Great Northern Railway referred to by Mr. Reid in his report. The unit described consists of two bodies only, mounted on three bogies, but the system has been extended to units consisting of five bodies mounted on six bogies.

This arrangement is of particular interest to railways considering electrification. The amount of electrical energy consumed is practically proportionate to the weight of the vehicles, and as by this arrangement the weight of the trains can be considerably reduced, the consumption of electricity would be reduced proportionately.

Mr. Biard. (In French.) — The Orleans Company have for several years now used twin carriages, the chief object being to use up old bodies which are mounted on bogies. I do not think that the system has been used in France for new stock.

Mr. Duchatel. (In French.) — The system which has just been described seems to me to be of extreme interest. It is not disputed that it gives advantages and especially economy in traction, but one must ask oneself if these advantages are not counterbalanced by certain inconveniences which arise in operation and maintenance. It would seem, in fact, that when one of these articulated carriages is damaged, the whole group is put out of service, and this would be a serious inconvenience to the operating department which deals with the make up of the trains. I also believe that in case of trouble with one of the parts, a hot box for example, that the whole group is put out of service and even may have to be sent to the shops. In regard to maintenance, the difficulties are not so great.

We shall be very happy to have an explanation on these various matters from an English colleague.

Mr. Gresley. — The Great Northern Railway adopted this arrangement for the conversion of old carriages, but the results obtained were so satisfactory that it was decided to adopt the arrangement for new vehicles.

One dining car unit, consisting of five bodies on six bogies, has been in service for eight months. The kitchen car on this train is fitted with electrical cooking appliances. This is the first electrical cooking installation on any railway train.

As to the necessity for withdrawing a whole group from service in the event of damage, I would point out that in England, particularly on suburban services, it is the custom to couple all the coaches of a train permanently together, which makes it necessary to withdraw the whole train in the event of anything going wrong with any of the vehicles; therefore no greater inconvenience occurs in consequence of the use of articulated trains.

Mr. Duchatel referred to hot boxes : I would point out that hot boxes in carriage stock are a rare occurrence, perhaps only two or three per month, and we have never had one on these articulated trains, therefore the objection to the system I have described has very little substance.

Lt. Col. Kirkhope, Oudh & Rohilkhand Railway, British India. — I should like to obtain some further information. In the ordinary system in which the underframe rests on two complete bogies the points of support of the frame are relatively close together, while in the articulated system where the points of support are at the extreme ends of the frame they are comparatively far apart. This being so in the latter case a heavier underframe would be required for the same strength. This increase in weight would seem to detract from the merits of the articulated system.

Again the shifting of the points of support to the ends of the underframe will cause the centre line of the frame to swing out less on curves. I should like to know how this has affected the possible width of vehicles.

Mr. Gresley. — It is quite correct that the underframe of a coach must be strengthened owing to the bogie centres being further apart, but this increase of weight is more than compensated for by the reduction of weight due to elimination of draw and buffing gear.

With regard to the suggested difficulty due to clearance going round curves, it is not possible by the use of articulated coaches to increase the width of the stock, the bogie centres being the same as with ordinary coaches.

Mr. Biard. (In French.) — This system of articulated trains is undoubtedly interesting, but I believe that everyone recognises that it can only be used in certain particular cases. In general service the necessity of having each carriage independent seems absolutely necessary. With international expresses and long distance trains it is becoming more and more customary, with a view of providing direct communication between the principal towns, to add, at certain points on the route, carriages known as through carriages. It would be a matter of difficulty, as well as being unnecessary, to use units larger and heavier than an ordinary carriage, especially where the latter provides the necessary seating accommodation.

As a consequence of this, I feel that the whole section, whilst greatly interested in Mr. Gresley's communication, ought to get back to the particular consideration of safety and comfort, because they are the two points on which we ought to devote our attention. I will ask Mr. Gresley if, from the point of view of safety in particular, he thinks that the arrangement he has mentioned has any advantage over other methods.

Mr. Gresley. — Some years ago an accident happened on the Great Northern Railway. Two trains running in the same direction (one composed of articulated vehicles) met on converging points. The whole of the articulated train was derailed, and although the coaches were sloping they were not overturned and none of the passengers were injured. If the trains had been composed of the ordinary four-wheeled stock the couplings would have broken and the vehicles would have fallen on to their sides, and there would have been many casualties. The couplings of articulated coaches are very much stronger than ordinary couplings.

I recognise that the traffic conditions on the Continent are not the same as in England, but I would point out that articulated carriages are used on the through Scotch services and that these trains are made up of coaches or groups going to various destinations. Of course if each vehicle forming the train is to go to a different destination, it would not be practicable to use articulated stock, but if two or more vehicles go to one destination then units made up in this way can be employed.

The President. — If no one else wishes to speak, the discussion is closed.

I will ask the committee of reporters to submit to us later the proposed summary.

PARAGRAPH B. — INTERNAL ARRANGEMENTS OF CARRIAGE BODIES.

The President. — Paragraph B contains a series of general summaries which will make it very difficult to discuss. I will ask the reporters to submit a more concise wording to us. (*Agreed.*)

This will be sufficient.

Paragraph C has already been dealt with.

We will now consider paragraph D : DETAILS OF CARRIAGE FITTINGS.

I believe that the section will agree to my asking the reporters to prepare a summary on this also. (*Agreed.*)

We will now deal with paragraph F : MAKE-UP OF TRAINS. The preceding paragraph E, dealing with VARIOUS APPLIANCES has already been considered.

Mr. Bochet wishes to speak.

Mr. Bochet, Ministry of Public Works, France. (In French.) — I believe that the introduction of the idea of homogeneity in No. 34 is the result of a misunderstanding. I know that in France in particular the question has often been raised. If we trace the origin of the idea, we find that when carriages have been built, with long wheel base and of heavy weights, to run in high speed trains, there have not been, at first, sufficient of these vehicles, and small carriages have had to be added to make up the trains, with the result that an unfortunate situation has arisen, as far as rolling is concerned. From this one has been led to say that it is necessary that trains to run at high speed must be made up entirely of carriages with long wheel base and heavy weight, that is to say, vehicles which comply with the conditions laid down by the reporter in paragraph No. 35. A fast train, composed of small heavy vehicles only, would be homogeneous and nevertheless will roll badly. On the other hand, a slow train usually made up of small heavy vehicles may without trouble have attached to it long heavy carriages intended for fast trains. It then ceases to be homogeneous without, however, becoming in any way bad from a safety standpoint.

I think, therefore, that we shall better express the ideas we have if we cut out this reference to homogeneity, and if we confine ourselves to recording one's interest in the arrangements which are set out in No. 35.

I propose, therefore, that No. 34 be deleted.

Mr. Biard. (In French.) — I am in accord with Mr. Reid that the deletion proposed by Mr. Bochet be agreed to.

The President. — The summaries as modified are adopted, but the committee of reporters will let us have a fresh text.

We will decide later on the resolutions which they will submit to us for the various paragraphs.

Tomorrow morning, after the end of our meeting, we are to join the third section to discuss the question of « Cab signalling on locomotives ».

Meeting held on 27 April 1922 (morning).

Mr. VAN LOENEN MARTINET, VICE-PRESIDENT, IN THE CHAIR.

The President. — I call upon Mr. Biard to read the summary.

Mr. Biard. (In French.) — The committee of reporters presents to the section the following summary :

« 1° The comfort and safety of the passenger, as well as economy in first cost and maintenance, have been the determining factors in the design and construction of the passenger carriages of the railway administrations of all countries.

« A. — *General arrangement of carriages.*

« 2° The bogie type of carriage is used exclusively in America. Its use is increasing in other countries and tends to become general for express and long distance train service.

« 3° The four-wheeled bogie is usually considered adequate, so long as the weight carried is not so great that the six-wheeled bogie becomes necessary.

« In England experiments have been made on articulated trains, one bogie being common to two carriages.

« B. — *Internal arrangement of carriage bodies.*

« 4° Vestibule coaches with through connections are exclusively used in the U. S. A.; there is a tendency for this system to extend to other countries for long distance trains.

« On many trains, however, coaches with side doors and corridors, in some cases communicating throughout the train are used.

« C. — *Type of construction.*

« 5° The use of all metal or nearly all metal carriages has developed rapidly in North America. This method of construction is now generally adopted there and is considered to reduce to a minimum the risks attendant on derailments, collisions and fire.

« In Europe metal construction has not been applied to any appreciable extent, except in the case of electrified lines. On certain lines, however, steel construction is being considered with a view of reducing fire risk; it is not intended, however, to approach the weights of the American coaches which have been partly incurred owing to additional comfort provided for passengers.

« D. — *Details of carriage fittings.*

« 6° The comfort provided in modern carriages is mainly due to the methods adopted for the distribution and division of the compartments, to the increase of air space and to the area allowed per seat, to the upholstery of the seats, to the ventilation, to the internal decoration, and to the numerous improvements that have been introduced in the smallest details.

« 7° It has not been found that the use of either of the two types of coaches, *i.e.*, side door or corridor had any effect on the frequency of criminal attacks.

« The most effective method is to arrange alarm gear within reach of the passengers, and easily accessible, for warning the train staff or operating the brakes. The general tendency is to allow the passengers to effect the stoppage of the train rather than merely slowing the speed.

« Small windows in the partitions between carriages (*glaces dormantes*) are also required in various countries.

« E. — *Various appliances.*

« 8° *Lighting.* — Notwithstanding the safety devices introduced, gas is now, in some countries, considered to be dangerous and to be liable, if not to cause, at least to increase fire following on collision. Electricity, particularly for this reason, tends to replace gas completely.

« 9° *Heating.* — The method of heating by steam from the locomotive is becoming more and more widespread. Recent improvements have been made with the object of better ensuring the flow of the steam to the last carriages of the longest trains, and to allow of the regulation of heat in the carriages or in the compartments.

« 10° *Brakes.* — The use of continuous quick acting brakes has been extended on nearly all the railway systems : trials have been carried out to increase the rapidity of action and effectiveness of the brakes on trains which run at very high speeds, and which have become of increased length and increased weight.

« F. — *Make up of trains.*

« 11° Safety in running is considered as ensured if each of the vehicles, taken singly, is capable, by reason of its weight per axle and its wheel base, of travelling at the maximum speed of the train.

« Owing to this, nearly all railways systems insist on either a minimum wheel base or a minimum weight for all vehicles that are to be made up into fast trains. Some administrations, in addition, require the grouping in a certain order, or in a definite position in the train, of those carriages which do not conform to the conditions laid down for weight and wheel base.

« 12° Other rules have been laid down regarding the interposition of buffer carriages at the front and rear of trains, the maximum number of carriages or axles per train according to the speed, the gradient, and the type of engine.

« 13° It is desirable that improvements and the application of such improvements may continue to be carried out as far as the increased financial burden due to these remains proportionate to the end to be attained and compatible with the economic position of each administration or of each country. »

— This summary was adopted.

DISCUSSION AT THE GENERAL MEETING

Meeting held on 28 April 1922 (morning).

Mr. R. DE CORNÉ, HONORARY VICE-PRESIDENT, IN THE CHAIR.
GENERAL SECRETARIES : Mr. J. VERDEYEN; Mr. E. FRANZA; Sir HENRY FOWLER.
ASSISTANT GENERAL SECRETARY : Mr. N. GIOVENE.

Sir Henry Fowler, *general secretary*, read the

Report of the 2nd section.

« (See *Daily Journal of the session*, No. 8, p. 5 and No. 9, p. 8.)

« Mr. BIARD (*special reporter*) read the general conclusions of his special report.

« THE PRESIDENT said it would be inconvenient to discuss these conclusions one by one, the section could, however, by means of a general discussion examine some of the more important items, and he proposed that they should commence with steel cars. On the New York Metropolitan, steel cars had been used for several reasons, the principal being the desire to render them fireproof and the presence of electrical equipment. On the Pennsylvania Railroad, the chief point for their use was the fact that access to the station was obtained through a long tunnel. The New York Central were faced with the same problem.

« Mr. Biard was in agreement with the suggestion and thought that they should adopt for their final summary the scheme laid out by the reporters.

« Mr. Reid (*reporter*) said that in England what they did in connection with steel vehicles was limited by the loading gauge and the weight per axle. The introduction of steel vehicles would increase the weight to be hauled per passenger. It should be pointed out that side doors and corridors are now regularly adopted for new stock in England. In that country it is considered better to look for safety by the improvement of signals than by building carriages better able to resist damage in the case of derailment and accident.

« Mr. Tollerton (*reporter*) remarked that in America journeys are often of great length, and the provision of greater comfort is looked upon as of more importance than the trouble arising from an increase of weight. The repair of steel built vehicles is much easier than those built of wood, rarely more than repainting is required.

« Mr. Van Schouwenburg (*Dutch East Indian Railways*) said that the construction of American vehicles required to be of a more robust character because of the central coupling and the blow required to operate this.

« Mr. Van Loenen Martinet (*Dutch State*). — In Holland they were proposing to employ of steel for two reasons : 1° because of the much greater strength with equal weight; and 2° because of the greater ease in repair.

« The President. — Steel vehicles are not necessarily much heavier than wood, perhaps 10 %. He gave figures with regard to the weight of American vehicles per passenger.

« Mr. Reid. — The figures just given by the President confirm his opinion that the steel vehicles are considerably heavier. In Europe they were generally limited to making the panels of steel. In suburban services the weight of the vehicles having a steel underframe and wooden body amounted to 600 lb. per seat, while with steel it reached 900 lb., and if it was required to give a greater strength with a view to collisions, in the lines of the United States practice, the weight per passenger reached 1 400 lb.

« The President. — In America one reaches these weights with wooden vehicles.

« Mr. Cooper (*City & South London Railway*) said that on the London Metropolitan District (partly under ground and partly suburban) which had all metal vehicles, it was found that these were not wholly a success. As far as noise, cold and appearance were concerned, they were less satisfactory than the other type. The tendency in England was to use steel for the underframe and for the framing of the body, using a certain amount of wood in the body proper; this was partly on account of it being cheaper than all metal construction.

« The President requested the reporters to come to an agreement on paragraphs 18 and 19 (steel vehicles).

« The President proposed that the question of lighting and heating be now dealt with.

Discussion on section *E*.

« Mr. Reid asked what was the policy on the continent with regard to lighting by gas or electricity, and in the latter case, which system was preferred (a dynamo for each coach or the lighting of two or more carriages by a somewhat larger equipment).

« Mr. Biard. — In France lighting by gas had been the rule; electricity cost nearly double. In consequence of the accident in the Batignolles tunnel, the Government had now insisted on the installation of electric lighting. The system adopted is that of a dynamo on each vehicle.

« Mr. Van Loenen Martinet. — Electric lighting of coaches in Holland began in 1910 with a dynamo per vehicle. The cost per vehicle was a little less than double that of gas lighting, but one was now able to get a certain economy by using a single battery and more economical electric lamps.

« Mr. Tollerton. — In America electric light costs half that of gas.

« Mr. Glover (*Great Northern Railway of Ireland*). — All the vehicles on his railway are electrically lighted for reasons of comfort. To attend to the electric lighting of 600 coaches they only required eighteen men. The batteries had a life of eight or nine years.

« Colonel Pringle (*British Government*) said he was in favour of electric lighting, which he thought was safer, and he said the British authorities are pleased to be able to state that the railways have commenced changing over gas lighting to electric lighting.

« Mr. Jacqmin (*Belgian State Railway*). — The Belgian State Railway only employ equipment with dynamos on each coach. The system with which there is one dynamo on the locomotive has been abandoned.

« The President asked the reporters to draw up the final text for paragraphs 29 and 30 (lighting). He then raised the question of heating for discussion.

« Mr. Barnet Lyon (*Dutch Government*) raised the question of the heating of trains on electrified lines.

« Mr. Glover said that as the results of tests he had found that it was not possible to heat a coach by means of a dynamo driven from an axle.

« Mr. Van Loenen Martinet thought that this matter really belonged to the question of electric traction and wished to leave out the paragraph relating to heating by steam from the locomotive.

« Mr. Biard insisted on keeping this paragraph in; the system was in general use, in France particularly so.

« The President passed to the discussion of the conclusions regarding brakes.

« Mr. Reid said that this subject was so large a one that he proposed it be not discussed.

« The President approved of this and the section agreed with this conclusion.

« The President opened the discussion on sections *B* and *D*.

« Mr. Süss (*Madrid-Saragossa-Alicante Railway*) proposed that alarm buttons should be placed in each of the four corners of the compartments as the alarm gear at present used is too high. He suggested that the text of the summary should be altered accordingly.

« Mr. Duchatel (*Eastern Railway of France*) remarked that this system had already been tried in France and abandoned because of the improper use made of it and because it was not efficient.

« Colonel **Pringle** agreed with this view.

« Mr. **Süss** pressed that a note should be made stating that a better type of alarm signal was desirable.

« **The President** asked the reporters to draw up jointly a text for paragraphs 18, 19, 27, 29 and 30.

« At the afternoon meeting, Mr. **Biard** read the new summary on questions dealing with metal vehicles (Nos. 18 and 19), lighting (29 and 30), heating (31 and 32) and brakes (No. 33). These proposals were adopted without discussion.

« Mr. **Gibbs** did not take the chair, which was occupied by Mr. **Van Loenen Martinet**, vice-president.

« **The President** opened the discussion on section *A*.

« Mr. **Gresley** (*Great Northern Railway*) supplied information as to the twin carriages used in his railway.

« Mr. **Biard** said that the Paris-Orleans Railway also had twin vehicles which enabled them to utilise old coach bodies.

« Mr. **Duchatel** criticised the arrangement, pointing out the inconvenience which arose in case of derailment or accident.

« Mr. **Gresley** stated that on the Great Northern Railway the system also originated from a desire to utilise old bodies. The results of trials however were such that the method of construction had been adopted for new coaches. The objections raised by Mr. Duchatel are not applicable, because in England the composition is the same as with other trains and hot boxes are extremely rare.

« Mr. **Kirkhope** (*Oud & Rohilkhand Railway, British India*) asked for information concerning the construction of this type of vehicle.

« Mr. **Gresley** said that the underframes were strengthened by the use of four tie rods in place of two, but this additional weight was more than compensated for by the saving in buffers and couplings.

« Mr. **Biard** found the system interesting, but only applicable to special cases, and did not think that the Congress could take it into consideration because it did not directly influence safety or comfort.

« Mr. **Gresley** said that after the experience he had had, he thought that the articulated train gave greater safety. Continental practice was not the same as in England, where a train was made up of several articulated coaches.

« **The President** suggested that the reporters should put forward a shortened text for section *A*.

« Dealing with section *B*, the president asked if any member had observations to make, and as no one had any remark, he asked the reporters to agree on a text between them.

« The same procedure was taken with regard to section *D*.

« With regard to section *F*, Mr. **Bochet** (*French Government*) considered that there might be a misunderstanding because of the use of the word « homogeneity » in paragraph 34, and proposed that the paragraph be deleted.

« Messrs. **Biard** and **Reid** agreed to this and the text of section *F*, as modified, was adopted.

« Mr. **Biard** read the following summary, which was approved by the section without discussion. »

The President. — This is the

Final summary.

« 1° The comfort and safety of the passenger, as well as economy in first cost « and maintenance, have been the determining factors in the design and con« struction of the passenger carriages of « the railway administrations of all coun« tries.

« A. — *General arrangement of carriages.*

« 2° The bogie type of carriage is used « exclusively in America. Its use is in« creasing in other countries and tends « to become general for express and long « distance train service.

« 3° The four-wheeled bogie is usually « considered adequate, so long as the « weight carried is not so great that the « six-wheeled bogie becomes necessary.

« In England experiments have been « made on articulated trains, one bogie « being common to two carriages.

« B. — *Internal arrangement of carriage bodies.*

« 4° Vestibule coaches with through « connections are exclusively used in the « U. S. A.; there is a tendency for this « system to extend to other countries for « long distance trains.

« On many trains, however, coaches « with side doors and corridors, in some « cases communicating throughout the « train are used.

« C. — *Type of construction.*

« 5° The use of all metal or nearly all « metal carriages has developed rapidly « in North America. This method of « construction is now generally adopted « there and is considered to reduce to « a minimum the risks attendant on de« railments, collisions and fire.

« In Europe metal construction has not « been applied to any appreciable extent, « except in the case of electrified lines. « On certain lines, however, steel con« struction is being considered with a « view of reducing fire risk; it is not « intended, however, to approach the « weights of the American coaches which « have been partly incurred owing to ad« ditional comfort provided for passen« gers.

« D. — *Details of carriage fittings.*

« 6° The comfort provided in modern « carriages is mainly due to the methods « adopted for the distribution and divis« ion of the compartments, to the increase « of air space and to the area allowed per « seat, to the upholstery of the seats, to « the ventilation, to the internal decor« ation, and to the numerous improve« ments that have been introduced in the « smallest details.

« 7° It has not been found that the « use of either of the two types of « coaches, *i. e.*, side door or corridor had « any effect on the frequency of criminal « attacks.

« The most effective method is to ar« range alarm gear within reach of the « passengers, and easily accessible, for « warning the train staff or operating « the brakes. The general tendency is to « allow the passengers to effect the stop« page of the train rather than merely « slowing the speed.

« Small windows in the partitions be« tween carriages (*glaces dormantes*) are « also required in various countries.

« E. — *Various appliances.*

« 8° *Lighting.* — Notwithstanding the « safety devices introduced, gas is now,

« in some countries, considered to be dangerous and to be liable, if not to cause, « at least to increase fire following on « collision. Electricity, particularly for « this reason, tends to replace gas completely.

« 9° *Heating.* — The method of heating « by steam from the locomotive is becoming more and more widespread. Recent improvements have been made with « the object of better ensuring the flow « of the steam to the last carriages of the « longest trains, and to allow of the regulation of heat in the carriages or in the « compartments.

« 10° *Brakes.* — The use of continuous « quick acting brakes has been extended « on nearly all the railway systems : trials « have been carried out to increase the « rapidity of action and effectiveness of « the brakes on trains which run at very « high speeds, and which have become of « increased length and increased weight.

« F. — *Make up of trains.*

« 11° Safety in running is considered « as ensured if each of the vehicles, taken « singly, is capable, by reason of its « weight per axle and its wheel base, of « travelling at the maximum speed of the « train.

« Owing to this, nearly all railway systems insist on either a minimum wheel « base or a minimum weight for all vehicles that are to be made up into fast « trains. Some administrations, in addition, require the grouping in a certain « order, or in a definite position in the « train, of those carriages which do not « conform to the conditions laid down for « weight and wheel base.

« 12° Other rules have been laid down « regarding the interposition of buffer « carriages at the front and rear of trains, « the maximum number of carriages or « axles per train according to the speed, « the gradient, and the type of engine.

« 13° It is desirable that improvements « and the application of such improvements may continue to be carried out « as far as the increased financial burden « due to these remains proportionate to « the end to be attained and compatible « with the economic position of each administration or of each country. »

— The general meeting ratified this summary.

[621 .33]

QUESTION VIII

ELECTRIC TRACTION

Electric traction on lines with dense traffic; production and transmission of energy; type of current; locomotives, motor cars. Technical and financial results obtained. Comparison with the results of steam traction.

Preliminary documents.

1st report (Switzerland), by Mr. E. Huber. (See English edition of the *Bulletin* of October 1921, p. 1357, or separate issue [with red cover] No. 32.)

2nd report (Sweden, Norway and Denmark. (by Mr. I. Öfverholm. (See English edition of the *Bulletin* of November 1921, p. 1934, or separate issue [with red cover] No. 44.)

3rd report (Italy), by Mr. A. Donati. (See English edition of the *Bulletin* of December 1921, p. 2175, or separate issue [with red cover] No. 48.)

4th report (Holland and Great Britain), by Mr. J. J. W. van Loenen Martinet. (See English edition of the *Bulletin* of October 1921, p. 1441, or separate issue [with red cover] No. 32.)

5th report (America), by Mr. G. Gibbs. (See English edition of the *Bulletin* of December 1921, p. 2091, or separate issue [with red cover] No. 47.)

6th report (all countries, except Holland, Great Britain, Belgium, Denmark, Norway, Sweden, Italy, Switzerland and America), by Mr. Sabouret. (See English edition of the *Bulletin* of January 1922, p. 107, or separate issue [with red cover] No. 52.)

7th report (Belgium), by Mr. E. Gerard. (See English edition of the *Bulletin* of May-June 1922, p. 763, or separate issue [with red cover] No. 64.)

Special reporter : Mr. E. Gerard. (See English edition of the *Bulletin* of April 1922, p. 731.)

SECTIONAL DISCUSSION

Meeting held on 20 April 1922 (morning).

Mr. G. GIBBS, PRESIDENT, IN THE CHAIR.

Mr. Van Loenen Martinet, *vice-president and reporter.* (In French.) — Gentlemen, we are commencing the discussion on question VIII. This question has been the subject of many reports as well as of the special report of Mr. Ernest

Gerard, which includes a general summary and draws attention to some matters on which Mr. Gerard thinks that the discussion may be of interest.

I think, Gentlemen, that if we start the discussion on this question in general, we shall immediately fall into confusion and anarchy. I therefore propose that Mr. Gerard should read us his summary and should state those points which he would like to hear discussed. We shall then be able to see whether the discussion should begin on these points, whether some of them should be set aside, or whether others should be added to them : and in this way we should settle the various points to be taken in the discussion.

(Mr. Gibbs, the President, having entered took the place of Mr. Van Loenen Martinet in the chair.)

The President. — Are the members here present in agreement to adopt the method of procedure indicated by Mr. Van Loenen Martinet. No opposition being manifested, I declare the latter's proposal adopted and I shall ask Mr. Gerard to read his summary.

Mr. Gerard, *special reporter*. (In French.) — Gentlemen, the yellow pamphlet containing the special reports that have been sent in on all the questions submitted to the Congress having been lost in one of the Italian railway stations, after having been for a long while on the way here, it was only possible to distribute it to you yesterday. These special reports give a summary of all the data comprised in the reports that have been drawn up on each question, and, in order to obtain an idea of the contents of these reports, it is only necessary to read the four of five pages of the special report in which they are summed up.

I hope that the greater number of you will have been able, since yesterday, to look through my special report on question VIII.

I think it well to draw attention to the fact that the General Management of the Italian State Railways has pointed out that in the report on the question of electric traction drawn up by Mr. Donati (1), there appear opinions on the ventilation system adopted in many of the Italian tunnels.

The Management thinks that the opinions set out by the reporter are of such character as to give the reader an unfavourable impression regarding this system.

The Management adds that the artificial ventilating installations in the tunnels, arranged on the Saccardo system, have always worked with great regularity and have proved of very appreciable advantage in working.

It only remains for me to read the proposed resolutions and the list of questions which conclude this special report.

As I have said, finally, this proposed list of questions is only an indication of the lines on which the discussion may take place and is in no respect limited. If therefore, after I have read it to you, any members desire to add any other questions, they are free to do so and we will begin in this manner by settling the programme to be followed in the discussion in such a way as to make it systematic.

Conclusion and questionnaire.

The above general synopsis shows clearly that without wishing to limit the range of questions that will be put at the Congress at Rome on the electrification of the large railway systems, it will be possible this time to direct the discussions of the 2nd section to subjects of practical interest put forward by the reporters.

---

(1) See *Bulletin of the International Railway Association*, December 1921, p. 2210, 2nd column (page VIII-200 of the separate issue [in red cover], No. 48.

1. — From the statements of the reporters taken as a whole concerning the relative value of the principal forms of energy applicable to the electrification of railways, we are inclined to conclude that the question « which is the best » will no longer be asked, but rather « under what circumstances should any one of them have preference ».

2. — The point on which all the reporters seem to agree, is the uselessness of standardisation of the current in the contact wire on account of the ease with which locomotives may be changed at the frontiers of the different countries. This question might raise discussions of a political nature which are against the custom of the Railway Congress.

3. — Does the argument, which does not accept as an advantage of the unification of any particular system of electrification on the two sides of a national frontier, apply where the question is one of two districts of the same country, differing geographically, the one mountainous, abounding in waterfalls, the other fairly flat and on the borders of which changes are already being made from steam traction ?

4. — It is unanimously desired that the methods of compiling particulars relating to economy should be standardised, not by a system of book-keeping of each electrified group, but what might be called by an *international account*. We hope that at table of comparative *financial particulars will be discussed at a sectional meeting.*

It would be convenient to adopt for this purpose a common standard by which all particulars and results both technical and financial can be equally measured, for example, *by virtual ton-kilometre which is equivalent to ton-kilometre on a straight level line.*

Here are a few other questions inspired by the reports :

5. — *Is the longitudinal catenary suspension preferable to the simple transverse suspension, technically and economically ?*

6. — *Has the use of three-phase current at 50 periods given rise to practical results justifying its extended use for main line railways ?*

7. — *What type of current is the best for use with the Gearless motors, permitting the latter to keep their known advantages ?*

8. — *Is multitraction more suitable with one type of current than another ?*

It is of course understood that the above questions are only for guidance and are by no means the only ones that might be put.

The President. — I declare the discussion open.

Sir Henry Fowler, Midland Railway, England. — I should like to know if it is proposed to have a general discussion or whether the section is to discuss the subject point by point?

The President. — I think that the discussion should be limited to the general questions, such as adaptability of electric traction, advisability of adopting standards, the unification of the systems of energy supply, etc. It seems to me that the section would lose its time if it entered into the discussion of questions of detail of apparatus.

Sir Henry Fowler. — In engaging in a general discussion on the question as a whole, the section is in danger of straying from the various points.

The President. — I consider that the summary presented by Mr. Gerard should serve as a basis for discussion, but, as this summary has not been submitted to the other reporters, the latter would probably like to confer together and examine Mr. Gerard's proposed programme.

Sir Henry Fowler. — I think that, so as to have some order in the discussion, the points treated in the summary report of Mr. Gerard should be examined successively. I propose that we discuss the conclusions of this report paragraph by paragraph and I ask that the section be consulted on the adoption of this procedure.

— Sir Henry Fowler's proposal was adopted.

The President. — I declare, in consequence, that the discussion on paragraph 1 is open.

1. — From the statements of the reporters taken as a whole concerning the relative value of the principal forms of energy applicable to the electrification of railways, we are inclined to conclude that the question, « which is the best » will no longer be asked, but rather « under what circumstances should any one of them have preference ».

Mr. Semenza, Ministry of Public Works, Italy. (In French.) — I wish to point out that paragraph 1 does not allude at all to the economic aspect. I think that, so far as the technical point of view is concerned, we can say to-day that all the systems are good, or have been brought to the same degree of perfection.

The question of the value of a system is actually, as it is stated, a question of local conditions, but it is also an economic question. I propose that this should be added in this paragraph.

I wish to make a suggestion to help the proceedings. The Italian members of the 2^{nd} section, while maintaining their right to use their own language, are quite willing not to insist on the translation into Italian of the whole of the discussion. By this means time will be saved and the discussion rendered easier.

The President. — If we are agreed, remarks offered in English and in French will no longer be translated into Italian. (*Assent.*)

Mr. Lanino, Minister of Public Works, Italy. (In Italian.) — In my opinion, Gentlemen, it is not possible to separate the technical from the economic point of view. I think, moreover, that the two sides of the problem have been already set out in the abstract proposed by Mr. Gerard, and that this abstract should be understood in the sense that it is not a general solution that must be sought, but that the technical and economical points of view must be considered in each particular case.

Mr. Gerard. (In French.) — Gentlemen, those amongst you who have attended the previous congresses, and particularly the Congress held at Berne in 1910, will remember the very lively discussions — I will not say violent because technical men generally are not violent (*laughter*) — in any case the discussions that involved some heat, which took place on the question of the general adoption of single-phase current, of three-phase current or of multi-phase current. These was then a tendency to try to find whether it was not desirable to adopt a single type of current for the electrification of the large European railway systems.

At one time continuous current had been definitely condemned on the basis of the formula which showed that the loss by heating was proportional to the square of the quantity and involved the installation of cables of prohibitive diameters and weights.

Thanks to the great progress that has been made in the construction of motors, which has enabled high voltage continuous current to be used, other ideas have come to be considered. However this may be, at the time to which I have alluded, there was a tendency to adopt a particular kind of current, to the exclusion of continuous current.

I think that this tendency to endeavour to standardise the use of a particular kind of current does not exist to-day. At least this is my opinion, and I submit it for the consideration of the section. I will ask, therefore, if there is any one who will now argue for a universal standardization of a particular type of current? My impression is that the reports that have been sent in on Question VIII do not lead to this conclusion, but that they point to the contrary, that is to the conclusion that there are actually three types of current equally suitable according to the circumstances. Such is the progress that has been made since the Congress held in 1910, and such is the opinion expressed in paragraph 1 of the conclusions that are proposed; as Mr. Lanino has very well stated, it is a question not only of the technical, but also of the economical point of view.

M. Huber, *reporter*. (In French.) — Gentlemen, paragraph 1 of the conclusions appears to me to present no danger and to be perfectly acceptable. It does appear to me, however, that it will be necessary to modify the wording and to specify that, in selecting the best system to suit any given conditions, there may be as many different conclusions as there are particular cases. The truth of this remark has been, I think, borne out completely in practice. But the matter of interest to us to-day is not the electrification of a given line having well defined conditions, but rather the electrification of a railway system of lines having different characteristics. Now in the case of such a railway system there is no one « best » system, all systems can find advantages in their application among the various particular cases that are covered by the whole.

Sir Philip Dawson, London, Brighton & South Coast Railway. — I join with Mr. Huber who proposes the adoption of paragraph 1. Only I should like to add that the question of the electrification of railway systems is not the same in different countries because the conditions differ. In Italy, in Switzerland, even in France, the conditions are quite different to those existing in England or in the United States. In England it can be foreseen that the electrification which will be realised ten, fifteen or twenty years hence, will be limited to the suburban lines of the large towns, — to this will probably tend the conclusions reached by the commission, appointed by the British Minister of transports, — and the greater part of these electrifications will be probably made at 1 500 volts.

I should like to point out here that, under certain conditions, there is great economy in adopting, even for traction on suburban lines, a higher voltage and that, although a tension of 1 500 volts has been adopted and recommended by the commission of whom I have spoken, one of our railways, the South Eastern & Chatham Railway, is going to electrify its lines with a tension of 3 000 volts on the two bridges system. The Commission appointed by the Minister of Transports and of which I form part, has studied the question and the Minister has authorised the adoption of this system.

The same considerations apply to the

great lines. The Brighton Railway had commenced, twelve years ago, to apply the alternating current at the time when this system was more or less in its infancy. It actually continues to apply it because it is a question of great distance.

I therefore believe that it would not be possible to say anything else but what paragraph 1 says. The choice of a system depends on the conditions in which it must be applied, on the first costs and working expenses. In each country, each case should be examined apart.

Mr. Gerard. (In French.) — Sir Philip Dawson has, I think, encroached a little on the discussion of paragraph 2 and, at the same time, he has given a construction to paragraph 1 which is not quite the same as that given by myself and which has been so clearly accepted by Mr. Huber.

As Mr. Huber has said, paragraph 1 is rather non-committal, which is just as well in the case of a Congress in which too rigid conclusions are generally avoided. This summary should rather be considered in connexion with the procedure at previous congresses. At these, as I have just mentioned, the question was put in these terms : Must continuous current be definitely excluded? And, in the previous congresses, some speakers advised this exclusion and only took into consideration alternating current in its two forms.

It is particularly in this respect that progress is shown at the Rome Congress. To-day it is not a question of knowing whether one form of current should take the place of the others; it is a question of finding what are the conditions to which the three types of current that are at present held in favour by technical men are best adapted.

I think that the previous speakers have agreed in asking that the words « technical and economic » should be added to this paragraph. I do not see any disadvantage, but the contrary. Nobody appears to have asked that the solution of the question should be made subordinate to technical considerations alone, and I think, therefore, that we should adopt this addition unanimously.

Mr. Sabouret, *reporter*. (In French.) — I am entirely in agreement with the opinion expressed by Mr. Huber on the interpretation which should be given to paragraph 1 and I confess that I am also entirely in agreement with that which has just been given by Mr. Gerard. In fact, as Mr. Huber has said, it is no longer a question of knowing whether, on a particular line, any one system is preferable to any other. We are now concerned only with general schemes and we are only considering railway systems.

For a certain line a certain type of current will be preferable; for a certain other line, on the other hand, a different type of current would be better suited. But it is not possible to say that all these systems can be indiscriminately mixed up with one another. It is therefore necessary that, if not for a whole country, at least for a particular region, a selection should be made of a single type of current which may not be the best for each of the lines under consideration, but which will be the most suitable for the whole group of lines. The question is therefore very much more complicated than it would appear to be from the wording of this paragraph.

Yo know that in France, the question has been examined from the point of view of extreme unification : it has been accepted that only one type of current shall be used for all main line electrification schemes. Furthermore it has been decided that the primary distribution lines for current shall be also arranged of a uniform type. This method of procedure may be open to criticism, but I should like to show that we have been led to adopt it by the fact that to-day it is no longer a question of whether a single line or a limited group of lines will be electrified according to the most suitable system, but that it is necessary to consider the whole, and that, under these conditions, the question must be put in quite different terms.

Mr. Gerard. (In French.) — I should like, Gentlemen, to say a few words in reply to Mr. Sabouret, who, like Sir Philip Dawson, has encroached, I think, on the discussion on paragraph 2.

I wish to remind you, for the third and probably the last time, that the Rome Congress has to-day before it three traction systems, and that it is not discussing the question of ascertaining whether one of these three systems should be eliminated on account of the technical or economical disadvantages which it may possess; that all are to be taken into consideration and that it is probable that, in different countries, the only question to be discussed will be that of knowing to which conditions of railway working is any one of the three favourite systems best adapted. I wished to draw up paragraph 1 with this in view. Perhaps my wording has not been sufficiently clear, but that is what I wished to express. Paragraph 1 covers both the technical and economic points of view in respect that to-day there is a choice between the three systems and that this choice may be influenced by local conditions.

Mr. Sayers, Great Central & Midland Joint Committee, England. — In the examination of paragraph 1, it is in my opinion impossible to neglect the question of the induction on small current telecommunication lines from the traction contact wire.

The induction trouble cannot be overcome in Great Britain by removing the telecommunication lines from the railway lines as is done in other countries, particularly I believe in Switzerland, as the Government have an absolute right of way for their telegraph and telephone trunk lines along the railways. The Midland Railway, to whose management I have the honour to belong, has for a number of years been experimenting on a double track line of a length of about 9 miles. The results of these experiments have been to show that it is impossible to free the telephone and telegraph circuits from troublesome induction if they run alongside a railway electrified by single phase current with an overhead contact wire and rail return. The advantages of single phase, three phase and continuous current traction systems being otherwise about balanced, in my opinion in such a country as England this question of induction should turn the balance in favour of the continuous current system.

Mr. Van Loenen Martinet, *reporter*. (In French.) — Gentlemen, I should like to propose a slight modification in the wording of paragraph 1 as put forward by Mr. Gerard. I should say : « If a summary is made of the opinions expressed concerning the relative value of the chief forms of energy that can be applied to the electrification of railways, one is led to the conclusion, when it is a question of the electrification of a whole railway system, that the question is no longer that of ascertaining which of these forms is the best, but rather to which cases each of them can, from the economic and technical points of view, be preferably applied. »

Mr. Gerard. (In French.) — Certainly, we are in agreement.

Mr. Huber. (In French.) — Gentlemen, we are about to adopt a conclusion which recognises that the choice of a particular system for the electrification of a railway should depend on the special conditions applying to the whole of that railway system. As I have already stated I am in agreement on this point.

In reply to Mr. Sayers I wish to make it quite clear that we find ourselves, in Switzerland, under conditions which are perhaps quite special in their relationship to the conductors of weak currents that run alongside the tracks. Actually we have also a mass of conductors carrying weak currents running alongside our railway lines, but very often these conductors are so near to the railway that it is absolutely necessary to move them to a distance in order to erect the contact wire, and this has been quite independent of the type of current adopted. I do not know whether these special conditions are also to be found on other railway systems, but I do think it necessary to state that they cannot be passed over in silence when the single-phase electrification of the Swiss railways is mentioned.

It is true that the expense incurred in the changes that have to be made to the conductors of weak currents is of considerable magnitude. But notwithstanding this the telegraph and telephone Administration finds it to its own advantage as well as to that of the railway Administration. Very often, in fact, the telegraph and telephone Administration is afforded a good opportunity for re-arranging its conductors, increasing their capacity, replacing overhead lines, which are costly in upkeep and more difficult to work, by underground conductors which are at the same time more economical and reliable, etc. The railway Administration also finds this to its advantage, because taking into account the whole of our railway system, the single phase type of current costs less, both in cost of installation and in cost of working. I will admit nevertheless that this particular state of affairs in Switzerland is not necessarily capable of standardization, although Mr. Gibbs, in his report, arrives at a similar conclusion by comparing the first cost of installation of continuous current with that of single phase current.

Mr. Rennes, Andalusian Railways. (In French.) — In Mr. Ernest Gerard's special report there is a table of electrified railways in which two lines are mentioned in Spain, one 13.7 miles long and the other 34.2 miles long. The first is the only one running at present, the second being only a proposed line.

With regard to the disturbances produced in the telegraph circuits by alternating current, the Andalusian railway company has tried and adopted with success, for a portion of the Santa Fé line (extended from 13.7 to 18.6 miles the solution of the problem effected by replacing the earth return of the telegraph circuits by an overhead return wire carried on the existing poles. The earth ends of this wire are taken several hundred metres on the one side and on the other side of the beginning and the end of the alternating traction current conductor.

Special precautions have been taken for insulating the telephone apparatus and the telephone wires running alongside the line.

The President. — With your permission, I desire to offer a suggestion regarding conclusion No. 1, as stated in M. Gerard's paper. It seems to me that the wording might be made a little clearer. I think it is intended to say that no one system of electric traction can be recommended as « standard » for all situations, but that the local conditions should guide in the selection of a system. If the Congress can arrive at such a conclusion it would, I think, be very useful in heading off attempts which have been made to eliminate progress in the development of two or more very useful systems by premature standardization of any one system in its present stage of development.

Mr. Sabouret. (In French.) — I should like to propose a wording slightly different from that which was submitted to us just now. I should make no change at the beginning of the paragraph; I should only change the last two lines which I should word as follows : « but only to find which is best suited for a given group of lines requiring to be electrified on a uniform system ».

The whole of the difficulties arise from the fact that, in a group of lines, some of the lines have quite different characteristics from others. It is necessary to make a selection, taking one with another, in order to ensure the choice of that system which is most suitable, not to each individual line, but to the whole group.

In this wording I set aside completely a comparison of the systems with one another from an abstract point of view. I merely state that these are questions of kind which do not enter into consideration for a particular line, but for a definite group of lines, the problem of which is quite different and greatly increases the difficulty of selection.

Mr. Gerard. (In French.) — I do not agree with Mr. Sabouret. When we discuss paragraph 2 he can bring forward his arguments in favour of the standardization of a system over any particular large railway system. I have just submitted to the President another wording which appears to me to define the limits of the question rather better. The sense of paragraph 1 is this : to-day no particular system is the best under all conditions. Now I think that this is also the idea which Mr. Sabouret has in mind.

Mr. Sabouret. (In French) — It is moreover what I have just said.

Mr. Gerard. (In French.) — There is no other difficulty than that of selecting which of the types is actually best adapted to the circumstances under consideration.

Mr. Lanino. (In Italian.) — The proposal of the President, who has spoken of standardization, tends to carry the question on to ground which is purely electrotechnical, rather than on to that which concerns railways. Mr. Gerard's proposal fulfils exactly the conditions of the problem when it refers to the railway point of view. It is the same question which we set ourselves in Italy, twenty-five years ago, when we began to consider the problem of electric traction. We considered it from the point of view of railway working rather than from the point of view of application of the use of electricity.

The President. — It is not the railways who ask for standardization; they on the contrary, desire further perfection of systems before standardization.

Mr. Lieb, Secretary of State, United States of America. — I speak in the name of the producers of electricity for commercial purposes and also for the railways.

Everything that the railway delegates have said from their point of view, may be equally repeated by commercial companies concerning the generation and the production of the electric current as far as they are concerned.

I wish to assert that for commercial companies whose business is the generation and the production of current, no difference exists, between the two points of view and that our companies are ready to supply railways with the current which they desire, with the requisite characteristics, leaving the railways perfectly free to choose the system they prefer, because we are in a position to supply them what they want and do not wish in any way to influence their choice. (*Applause.*)

Mr. Parodi, Paris-Orleans Railways. (In Italian.) — I should like to ask Mr. Lieb if he is ready to supply current at 15 or 50 periods at the same cost.

A Delegate. (In French.) — That is not the question.

Mr. Parodi. (In French.) — Mr. Lieb has said that he would supply current of any periodicity; if the costs of current at 15 and at 50 periods differ, this will have an influence on the selection of the type of supply for the track; it is for this reason that I raised the question.

The President. — I consider the discussion of paragraph 1 has been sufficiently prolonged and that the section could now pass on to the discussion of paragraph 2. I think it will be difficult in a general meeting to arrive at the exact wording of the paragraph; I, therefore, propose to have the sense of the meeting incorporated in a resolution to be prepared by the reporters upon the subject after the meeting, and submitted for action by the section at tomorrow's session.

Mr. Gerard. (In French.) — I propose that the discussion on paragraphs 2 and 3 be taken together.

The President. — In effect, I think that paragraphs 2 and 3 are connected with one and the same subject, *viz.*, the utility of adopting one standard on the two sides of a frontier or in two distinct regions of the same country. I therefore place under discussion paragraphs 2 and 3, as follows :

2. — The point on which all the reporters seem to agree, is the uselessness of standardisation of the current in the contact wire on account of the ease with which locomotives may be changed at the frontiers of the different countries. This question might raise discussions of a political nature which are against the custom of the Railway Congress.

3. — Does the argument, which does not accept the necessity of the unification of any particular system of electrification on the two sides of a national frontier, apply where the question is one of two districts of the same country, differing geographically, the one mountainous abounding in waterfalls, the other fairly flat?

Mr. Gerard. (In French.) — In my special report I have pointed out what is in question in paragraph 3. In France one single system has been adopted for the whole of the country. I have asked whether any examination should be made as to whether, in a country of such an extent and comprising regions which are absolutely different, both in natural characteristics and in sources of production of electricity by hydraulic power, it would not be advisable to consider the following question : is it necessary, in a large country such as France, to standardize, by adopting a single system for all applications of electric traction?

On the other hand, I have drawn attention to the fact that in Italy much more breadth of view has been shown and the application of various systems has not been abandoned. This is the subject of the paragraph and I ask that the discussion shall take place on this point.

Mr. Sabouret. (In French.) — I am quite in agreement with Mr. Gerard over the wording of paragraph 2 which no one has raised objection to; but I am, on the other hand, in complete disagreement with him over paragraph 3 which I ask should be cut out.

I think it would be better to argue from the consideration of particular cases rather than by basing an opinion on general questions : this will be the way to arrive at a better understanding and I am accordingly going to speak about the Orleans railway system. The Orleans Railway Company, extends from Paris to Toulouse, its southern extremity 435 miles away, and it is proposed to electrify the whole of the main line from Paris to Toulouse, and the whole of the branches running from the southern end; the total length to be dealt with will exceed 1 550 miles. On the first half of the 435 miles of the main line, the line runs through country which is quite flat and some distance from any water power. On the other hand all the southern lines serve a mountainous region that is rich in waterfalls. Was it advisable to apply to the northern section a different system of traction to that used for the southern section? We have not thought so and we have decided in the negative.

When the question is examined closely, excellent reasons are found for justifying standardization. To supply the whole length of about 2 175 miles of line which it is proposed to electrify, we have at our disposal two sources of power. The first is derived from the convenient sources of water power in the southern district; the second, or auxiliary supply, will consist in a steam plant which will be installed in Paris and which will assist the other in the case of occasional inadequacy of the supply of water power.

By the construction of large reservoirs capable of balancing the seasonal fluctuations we shall be able to obtain a regular monthly output from our hydraulic supply stations.

But this will not overcome the difficulty that, during dry years, we shall have very much less water for the whole of the railway system than during wet years, and consequently, it will be necessary for us to have recourse, sometimes under very variable conditions, to the assistance that we can obtain from the steam plant installed in Paris.

We shall therefore have an intermediate district which will be supplied sometimes from the hydraulic power plant, and sometimes from the steam plant, and it is not possible to conceive this mutual assistance between the two power systems without complete standardization of the general distribution of power, and, consequently, of the type of current to be used in the electrification of the whole of the system.

I think that this example clearly shows that it may be possible to be driven into a standardization, which at first sight might appear unreasonable.

When the question is examined more closely it will be seen that the small advantage that could be gained by using on a length of 185 miles a system that is especially suitable to this portion of the line, and having a different system in use on the rest of the line, would only be obtained at very heavy cost.

Mr. Gerard. (In French.) — Gentlemen, it never entered my mind to criticize the work of the engineers of the Orleans Railway Company which led them to select such a type of current as the continuous current at 1 500 volts for the electrification of their railway system.

Nor do I desire that any false impression should be produced by the meaning of paragraph 3, which Mr. Sabouret proposes should be cut out and which I ask may be retained. The following are the terms of this paragraph.

If the particular case of the Orleans Railway Company is considered, Mr. Sabouret has just pointed out to us that it has knowingly adopted a single type of current for traction. But some time ago, I was over the Midi system on which, for local reasons, the single phase type of current had been adopted and I asked myself why this type of power transmission was being given up. Was it for the simple reason that the other railway systems were adopting a different system? Frankly, I do not yet see the economic or technical conditions which led the management of this railway system to give up a type of traction that had previously had a great attraction for them, so great in fact that they had made systematic trials of it on a large scale.

If we start from the point of view that it is advisable to avoid changing locomotives, I would draw attention to the fact that in a small country like Belgium, the Luxembourg line for example, which has very varying gradients, giving a sawtooth profile, is run over by steam locomotives which work almost exclusively on this part of the railway system. If, even with steam traction, we have actual change of locomotives at those points at which the character of the railway system changes, still more may such changes be required with electric traction, and it is for this reason that I have raised the question : is it necessary to standardize a system of traction over the whole area of each country?

On account of the natural configuration of the country there are large railway systems which present radical differences, such for example as those that exist between the Midi Railway system which runs through a mountainous district with numerous waterfalls, and the numerous railway systems of other parts of France, where there are no waterfalls and where the ground is flat.

Would it be maintained that the French Northern Railway system for example should necessarily be electrified with the same type of current as the Midi Railway system? Is there any reason whatever, either technical or economic for so doing? Is it not possible, on a railway system like that of the Midi, to find those conditions that have led our Swiss colleagues to adopt the single phase current? Do the telegraph wires play the same part in both cases? In these mountainous countries, would it not be better to modify the installations of the telegraph and telephone conductors rather than adopt the continuous current? This I think covers the question.

Sir Philip Dawson. — Mr. President, it seems to me that paragraph 3 is in reality nothing but a detail of the principle set uot in paragraph 1. If therefore we adopt this latter paragraph, paragraph 3 which is only a particular case of same, has no longer any « raison d'être ».

Mr. Van Loenen Martinet, *reporter*. (In French.) — In the first instance I should like to put a question to Mr. Sabouret. From the fact that the Orleans Railway Company desires to standardize the power distribution over the two districts of its railway system that are to be electrified, districts which differ greatly, perhaps, from the traction point of view, it does not appear to me to follow that in these two districts the kind of current used for the contact line need be the same. It astonishes me that the one idea of a uniform system of distribution should have decided the Orleans Company to adopt the same type of current for the two portions of its railway system.

Starting with the same primary type of current supply many technical or economical questions may lead to the adoption of one or another type of traction current. In this connection I draw attention to the following point. We know that one of the great advantages of electric locomotives, is that they can be driven by any member of the staff, and that they can therefore be run over very great distances. It may therefore happen that there are reasons for using two types of electric traction on the same railway system, but on the other hand, the fusion of the two types into one single type, in order to enable the locomotives to run for very great distances, has such advantages that they outweigh those of the other arrangement.

It appears to me, therefore, that paragraph 3 is of such a general nature that it would be better, in my opinion, not to discuss it any further.

Mr. Lanino. (In Italian.) — On the first point I think that it is not only the contact line that must be considered, but also the make-up of the trains that arrive at the frontier stations.

In the railway service carried on during the war, we have recently seen a case that was remarkable and interesting in the highest degree; it was the arrival at Modane station of military trains coming from France and continuing their journey in Italy. The trains that arrived from the French side had a high potential. It was possible to overcome this serious difficulty — which was a difficulty in railway working or what might be expressed as a difficulty of shunting trains in a station — thanks to the system of electric traction applied at Modane it was adaptable for running the trains that came from France even when they were hauled by three locomotives. Otherwise the installation at Modane would not have allowed of the concentration of French troops in October 1917. This is the question from the technical point of view.

With regard to the traction system used I find that the insistence of reporters on certain matters is well founded, because I am of the opinion that this problem should be considered not only as between one country and another, but also as between one district and another of the same country.

The special reporter has drawn attention to the fact that we have great breadth of mind in Italy, a point on which I congratulate myself because I think that in technical questions there is no system more dangerous than that which consists in reducing everything to a system.

Italy has a geographical configuration which perhaps renders this problem more important there than in any other country. Italy stretches into the Mediterranean like a pier of more than 370 miles in length, and whilst we have an Alpine region at one of the ends we have also a southern region at the other end in which we meet with totaly different conditions for the production of current, and particularly as regards its distribution and its consumption.

In northern Italy, we have an area which is essentially industrial, whereas in southern Italy industry is but little developed and the centres of consumption are almost exclusively situated on the coast line, and they represent but a small demand for power, both as far as the railways are concerned and from the point of view of industry. It therefore becomes necessary to look, as closely as possible, at a concentration of all the power-supply services.

I agree with what was said by Mr. Lieb (perhaps not so much on account of the reference he has just made to it, as on account of the allusions to some reports proceeding from his own country), by remarking that myself, who have been for twenty-five years one of the most convinced partisans of the three-phase system — having taken part in the first installations of the Valtellina line — have been forced to come to the conclusion that for southern Italy, in consequence of the necessity for concentrating all the supply services, and that of transport in particular, it would be necessary to take into consideration the transformation of this system itself.

Now, since we have the line from Rome to Sulmona and to Castellamare which cuts our country into two quite separate parts even for locomotive working, the two problems may be considered as being quite distinct.

The State railways are, in fact, considering the problem of making a trial of three-phase current at 50 periods in southern Italy; that it is to say of three-phase current of the type supplied for industrial purposes. (*Applause.*)

The President. — I consider that the discussion on paragraphs 2 and 3 may be closed, the vote on these paragraphs being put off till to-morrow morning's sitting. Discussion on paragraph 4 will now be taken up.

4. — It is unanimously desired that the methods of compiling particulars relating to economy should be standardised, not by a system of book-keeping of each electrified group, but what might be called by an *international account*. We hope that a table of comparative *financial particulars will be discussed at a sectional meeting.*

It would be convenient to adopt for this purpose a common standard by which all particulars and results both technical and financial can be equally measured, for example, *by virtual ton-kilometre which is equivalent to a ton-kilometre on a straight level line.*

Mr. Duer, Pennsylvania System. — I desire to present a few considerations relating to the precautions taken against the effects of induction on my system.

The President. — This subject is outside of the question under discussion; you will have an opportunity to discuss it later.

Mr. Duer. — I would draw the attention of the section to the difficulties of establishing an International Bookkeeping System, which would allow of properly comparing the different electrical systems. I think that the problem is difficult to solve. In my country, where different kinds of electrification have been applied, difficulties have been met in comparing them, because those who made the comparisons did not always follow the same plan, nor look at the problem from the same view point. In any program which is drawn up, the different conditions surrounding each electrification would have to be taken care of, so that in the results consideration would be given to these conditions. As an example, in cases of partial electrification, it would be very difficult to separate the part of the system which is electrified from the part which is not. This is one of the sources of difficulty which I have in mind.

Sir Henry Fowler. — I wish to draw the attention of the section to the term « virtual ton-kilometre ». I can say from my own experience that it is not possible to arrive at any serviceable and accurate method of arriving at this. In addition to the question of gradients and curves, there are many other variable quantities which must be taken into account. To quote only one of these points, the resistance of a train varies with its speed, and in addition to this point there are many others, and I think we can arrive at no definite conclusion on any point that depends on this unit of measurement of work.

Mr. Parodi. (In French.) — I am entirely in agreement with Sir Henry Fowler on the difficulty that exists in making use of the virtual ton-kilometre unit which has not got a perfectly clear meaning at the present time. I recall, that, in experiments made on the Pennsylvania Railroad, it has been found that the resistance of the load hauled is a function of the weight of the train hauled, rather than of the speed. For normal speeds of goods trains, the resistance of a vehicle to rolling bears a relation to its weight which, if plotted, would form a straight line. It follows that, when the weight increases, the resistance per ton decreases very rapidly. The notion of the virtual ton-kilometre, as it is understood in Italy and elsewhere, has not a definite meaning and therefore cannot be used without further definition.

Mr. Huber. (In French.) — Paragraph 4 appears to me to be of great interest and of extreme importance, but it seems to me that the question is at the same time both very difficult and very simple.

The virtual ton-kilometre is of course only an approximation which is a little more accurate than the ton-kilometre. Thus, the Bellinzona-Erstfeld line which is only 110 km. (68.4 miles) long measures 229 virtual kilometres (142.3 virtual miles), calculated from the formulæ given by Mr. Mauduit in his report made in 1920, to the higher Council of Public Works in France, on the electrification of the main-line railway systems. If threrefore, the line in question consumes at the present time, with a normal voltage of 15 000 volts, 37.4 watt-hours per ordinary ton-kilometre (61.2 watt-hours per ordinary English ton-mile), it only consumes 18.0 watt-hours per virtual ton-kilometre (29.4 watt-hours per virtual English ton-mile). This is an enormous difference and the want of exact information relating to the rolling resistance of the trains scarcely enters into the question, its influence being less than the difference between the ordinary ton-kilometre and the virtual ton-kilometre.

It therefore appears to me that the notion of the virtual ton-kilometre is really of some interest; but what seems to me to be more important, is that the authors should supply their information with greater exactitude than they have been in the habit of doing.

Thus, for example, Mr. Sabouret, in the report which he has prepared, shows that the consumption on the Chicago-Milwaukee is 26 watt-hours per ton-kilometre (42.5 watt-hours per English ton-mile) hauled.

This figure is the same as that given by Mr. Mauduit in his « Report of the investigating Committee to the higher Council of Public Works, on the electrification of main lines of railway ». This figure of 26 watt-hours per ton-kilometre (42.5 watt-hours per English ton-mile) hauled corresponds, according to Mr. Mauduit, to 22.2 watt-hours per total ton-kilometre (36.3 watt-hours per total English ton-mile) of the energy measured on entering the sub-stations. Now Mr. Murray, in his report of 1921,

« A super-power system for the district between Boston and Washington », gives the consumption on the Chicago-Milwaukee as 22.6 watt-hours per total ton-kilometre (37 watt-hours per total English ton-mile), an amount of energy which Mr. Murray states had been carefully measured at the supply terminals from the sub-station. In the first case, the losses in the sub-stations are included in the figures given; in the second case they are not included. This makes a great difference and there must be some error which I cannot explain.

I should not like to take up your time further on this subject, but I think there ought to be no doubt whatever on such a point as this. Neither Mr. Mauduit, nor Messrs. Japiot and Ferrand, nor Mr. Sabouret, give the efficiency of the sub-stations, an efficiency which Mr. Murray shows as averaging 83 %. This efficiency is given by Mr. Murray with the reservation that the figure had been supplied to him by the officials of the Chicago-Milwaukee line. Now such a figure for the efficiency of a station with motor transformers even with synchronisers and two generators, is absolutely an improbable one.

There should not be the least doubt as to the sense in which these data are to be taken. If there were no doubt it would not be necessary to give conventional co-efficients. We are technical men; we know very well how to handle figures when we know how they are to made up, but it appears to me that instead of discussing proportions and conventional co-efficients, it would be better to make sure that all the data given have been so obtained that they are not subject to any doubt. If we can arrive at this result it will not be necessary to introduce various kinds of ton-kilometres, etc.

Mr. Sabouret. (In French.) — My report says definitely, on page 221 (¹) that the consumption on the Rocky-Mountain line is 26.8 kilowatt hours per 1 000 ton-kilometres (43.8 kilowatt hours per 1 000 English ton-miles) hauled, the energy being measured on entering the sub-stations.

Mr. Gerard. (In French.) — Gentlemen, I am thoroughly in agreement with the previous speakers that the virtual ton-kilometre should not be retained absolutely as a basis for all the data. I would however, remark that a well-known French authority, Mr. Baume, the bridges and roads engineer, has written a work in which he has compared the actual cost on the various French railway systems by reducing the different lines to what he terms their virtual lengths and that he has found that the costs of working are directly proportional to the virtual lengths. The virtual length is therefore a method of reducing the rising and falling gradients and the curves to a definite length of level straight line. This unit has come into general use in the science of traction, and I think no one can take exception to it.

Of course the make-up and the speed of the train may have some part in this. Also I should not insist for a moment on the adoption of the virtual ton-kilometre as the sole unit. As Mr. Huber has said, if it were possible to obtain data of perfectly definite value, and if care were always taken to state that which is intended to be specified as the basis of consumption, no errors would be made like those which I made in my report by making a statement which Mr. Huber would not have made by as-

---

(¹) See *Bulletin of the International Railway Association*, January 1922, p. 116.

suming the point of leaving the substation as being the same as the overhead conductor itself. Now as the connecting wire is of a certain length, it is also necessary to take the resistance of this wire into account. I thought that from the moment the current had arrived at the connecting wire, the resistances would be considered at that stage at the relays.

It is therefore always necessary to specify with great care exactly what is given in the data. But I am not in despair of finding a method for establishing all these data on a common basis, because this has been done for all sorts of subjects that have been submitted to scientific investigation.

It is useless for me to dwell upon this point at this late hour, but I think that some sort of standardization is required. I do not insist that it should be the virtual ton-kilometre, but I do think it is desirable that we should find a standard.

The President. — I feel that I should warn the members against expecting too much from « standard account-headings » applied « internationally ». As will be seen from my report on Subject VIII : « Electric Traction », it is extremely difficult to draw correct conclusions as to relative operating costs between steam and electricity on the same railway; it is more difficult to make the comparison between different railways; and I should regard it impossible to arrive at any useful conclusion by comparing operating costs of railways in different countries using, as they do, different types of rolling equipment, train loading, speeds, etc. However, I do not mean to say that a standard form of keeping accounts would not be interesting and useful for some purposes; as more scientific unit for comparing locomotive performance than the « ton-mile », is certainly demanded; I trust this meeting will take action which will result in something being done along this line.

Mr. Semenza. — I wish merely to remark that all investigations dealing with steam traction based on the virtual ton-kilometre and on the virtual length have given very satisfactory results; but I recommend that the members here present should ascertain whether it is desirable to apply these same methods to electric traction without modification. I am of the opinion that it is necessary to adopt a different definition for the virtual ton-kilometre for electric traction from that adopted for steam traction.

Mr. Lanino. (In Italien.) — I ought to draw attention to the fact that the question raised by Mr. Semenza is perfectly clear. It was discussed before our College of Railway Engineers, in an elementary form, in a report by Mr. Verole, and the discussion turned on whether it was not necessary to determine a formula for calculating the virtual lengths for electric traction, which would be different from that for steam traction.

But in the present instance we fall back on one of the general problems before the Congress, instead of keeping within the limits of a special problem. In all railway questions there is a want of uniformity in the rules for the working out of statistical data, hence the great risk that occurs in making use of them. I will quote an example : The Italian Minister of Public Works actually drew my attention to the fact that we were spending 35 % more on the staff for the Italian railways than for the Austrian railways. The difference was so great that it was absolutely impossible for it to be true, and actually, the whole question turned on the fact that in the one case the temporary servants were taken into account and in the other they were left out.

It is therefore not a case of a particular problem for this section but of a problem of much more general range. Moreover, in my position as President of the College of Italian Railway Engineers, I have been engaged in a discussion with the President as to whether there is not adequate reason for making this problem the subject of a question, that is to say whether the Permanent Commission would not think it within its power to take the initiative in full session, at a future Congress, with a view to studying the question of the definition of fundamental units, with the object of obtaining precise statistical particulars such as would lend themselves to purposes of comparison.

The President. — As the hour is now advanced, I propose that we postpone further discussion until tomorrow's session. The meeting stands now adjourned.

Meeting held on Friday 21 April 1922 (morning).

Mr. G. GIBBS, PRESIDENT IN THE CHAIR.

The President. — We now resume the discussion of paragraph 4 of the conclusions in Mr. Gerard's special report.

Sir Henry Fowler. — I propose that this paragraph be replaced by the following :

« It is desirable that the methods of keeping and supplying technical and economical information on electric traction should be defined and standardised, and with this in view, the section suggests that this point be referred to a special committee of the Association. This committee should draw up very fully the details governing each point so that in future as full a comparison as possible may be made by means of figures absolutely comparable. »

This I think has the same meaning as the paragraph proposed by Mr. Gerard, but has I believe the advantage of not mentioning an absolute unit such as the virtual ton-kilometre, which has not, up to the present time, been clearly defined.

Mr. Gerard. — I am completely in agreement with Sir Henry Fowler in his proposal as to the manner of wording the paragraph and I hope that the Permanent Commission will accept his proposal and carry it out.

The President. — Sir Henry Fowler's proposal is then adopted and will be taken into account by the reporters in the wording of the definite conclusions.

The discussion on paragraph 5 is now open. This reads as follows :

5. — Is the longitudinal catenary suspension preferable to the simple transverse suspension, technically and economically ?

Mr. Pattison, Illinois Central Railroad. — The attention of the section is drawn to the necessity of providing two contact wires in certain cases. In my opinion, for tensions as low as 1 500 and 3 000 volts, it is necessary to have a double contact wire in order to permit the collection of the current required by locomotives. Exception to this requirement may be made for shunting lines, but for main lines where the locomotive is called upon to develop its maximum effort, the necessity of a good contact requires the use of two wires for these tensions.

For multiple unit trains, when several collectors are in contact with the conductor, this duplication of contact wires may not always be necessary.

On the other hand, for tensions of 11 000 volts or higher there is no need of duplicating the line even for the heaviest locomotives. I must add, however, that my remarks are not to be considered as the result of recent definite experiments by the railroad I represent, but as a conclusion resulting from investigations and studies that I have made.

Sir Philip Dawson. — On the Brighton, we have an overhead line which was put up in 1909 and on which, we have, at regular intervals, measured the diameter of the contact wire with a view to ascertaining the causes which produce wear of this wire. We have taken these measures on a section worked by electricity and by steam and on a section where electricity alone is used.

The first thing that we remarked was that where there is no consumption of current and no utilisation of steam, the wear is negligable. Some wires placed in 1909 and still in use only show a wear that is practically nil, in the order of one-hundredth of an inch, while about a thousand collectors have passed over these wires.

Where steam is used, we have found that, even when there is no consumption of current, there is a marked wear of the wire. This wear is probably caused by the deposit on the wire of products of combustion, whose action between the collectors and the wire should be compared to that of emery.

We ascertained that where the suspension of the wire was not absolutely flexible, a very appreciable wear resulted, this obliged us in many cases to renew the lengths of wire. Then we replaced the form of the insulators and of the suspension of the wire in use by different forms offering the same flexibility as in the parts of the line where there are no supports, and the wear immediately disappeared.

The third thing that we remarked is that the wear of the wire is a function of the current taken up by the collector. This is not a linear function. We have not yet all the data which should allow of establishing a formula, but we have verified that where the current exceeds 70 amperes per collector, especially when is exceeds 100 and reaches 120 and 140 amperes, the wear is very marked.

This is why for the new 1 000 H. P. motors which we now have running, we are going to employ two collectors instead of one, we wish to thus avoid the too rapid wear of the wire.

I will add that our collectors are inclined ones of the same kind as those employed on the Italian State railways and that the contacts are of aluminium and supplied with a slot filled with some lubricating matter and, sometimes, plumbago.

The President. — Will you not favor us with a statement of some of the reasons why you prefer the type of suspension you use?

Sir Philip Dawson. — On the Brighton, we have adopted the catenary suspension so as to have a wire as horizontal as possible in view of the great speeds at which the locomotives must run under the wire. We have also adopted this method of suspension for reason of surety, because of the enormous traffic which exists on our lines and which only allows us two hours per day for the examination and the maintenance of the trolley wire.

At Victoria Street Station, we have one thousand trains per day, we shall shortly have two thousand, and we have only five tracks in all for in and out trains. You will understand that we have very little time at our disposal and that we must attain great surety. It is for this reason that we have adapted catenary suspension and not simple suspension such as it is applied in Italy.

Mr. Van Loenen Martinet, *reporter*. (In French.) — Gentlemen, up to the present time there are very few railways carrying heavy traffic on which high-tension continuous current is used. Actually I only know of three examples : the Chicago-Milwaukee, the Sheldon-Newport and the Melbourne line.

The Sheldon-Newport line has slow traffic and cannot be used for comparison in regard to its contact line. But the case is quite different for the two other lines that I have just mentioned The Chicago-Milwaukee has two contact wires. The Melbourne line has a single wire 160 mm² (0.248 square inch) in section. It would be very interesting to know what has been the result of experience with regard to the taking of current and wear of the conductor.

At the date at which the French Commission visited America, the results obtained on the Chicago-Milwaukee line were very satisfactory; they were still satisfactory at the time when the Dutch Commission visited the United States. But even at that date the experiment had been only of short duration and I should like to know whether there are not amongst the members present some who could answer the following question : what are the results of the latest experiments made on the Chicago-Milwaukee line and on the Melbourne line?

Mr. Öfverholm, *reporter*. — In Sweden we use 16 000 volts single-phase current on our trolleylines for the State railways. For this purpose we have found that a single catenary trolleyline can be used with the best results. The distance between the poles for our trolleylines varies between 57 and 66 yards and the distance between supports for the trollley-wire — the connections from the trolley-wire to the catenary cable — varies between 14 and 22 yards.

Mr. Semenza. (In Italian.) — I had the opportunity of examining the Chicago-Milwaukee line in 1921 and I can give you the impressions I formed.

The line was in very good condition, the troubles that had occurred had not been numerous and had, in general, been due to atmospheric discharges (lightning). The wear of the wire was almost inappreciable. But, as you are aware, the number of trains running on this line is not large.

The system of arranging the two conductors side by side with alternate suspension has the advantage that the pantograph never touches the wire at its points of suspension, so that there are practically no variations in the inertia effect on the contact wire.

According to the information that I obtained eight men only were employed in maintaining a section 27 miles in length including the maintenance of the main supply conductors.

The President. — The most useful conclusion, I think, which can be drawn from experience with the Milwaukee & St. Paul contact line is that a « soft » line, *i.e.*, one free from hard spots which cause sparking, can be obtained by suspending two trolleywires from one catenary by alternately spaced hangers, when the overhead is free from complications of yard connections, etc.

Sir Philip Dawson. — Could not Mr. Semenza tell us what number of collectors pass each day under the wire of the Chicago-Milwaukee line?

Mr. Semenza. (In English.) — I am unable to give the number but what I can state is that, particularly lately on account of the slackness of trade, this number has probably been reduced.

Sir Philip Dawson. — About how many trains are there a day?

Mr. Semenza. — There are eight passenger trains and a varying number of goods trains.

Sir Philip Dawson. — There would be then from ten to twelve trains a day.

Mr. Semenza. — Yes, but they are very heavy trains.

Mr. Parodi. (In French.) — Mr. Van Loenen Martinet has raised the question relating to the working of railways with overhead contact when these lines carry a large number of trains. I think that an example of this exists in the Paris Nord-Sud line. It is perhaps the best example that can be quoted in this respect because the service on this line consists of a train every two or three minutes. It has been found that the wire which carries current at 600 volts and from which current is taken up to more than 1 000 amperes, shows no appreciable wear.

Referring to the Chicago-Milwaukee line, I had the opportunity of inspecting its installation last year. As in the case of the visit two years ago we found the working conditions to be quite satisfactory; there was no sign of sparking at the collector, whereas we had seen sparking on all high-tension current lines having a single conductor.

There is no reason to suppose that the wear of the wire on the Chicago-Milwaukee line should be greater than that which is found on the New York-New Haven or on the Norfolk & Western lines on which a great deal of sparking can be seen at night.

With regard to the flexibility of the line, as Mr. Semenza has justly observed, the use of two wires with alternate suspension gives the overhead conductor a remarkable softness. The bow never bears where the wire is suspended and by this means excellent working conditions are obtained.

Mr. Huber. (In French.) — It appears to me that the question of knowing whether the contact line of the Chicago-Milwaukee Railway is more or less perfect does not arise out of the question raised by M. Van Loenen Martinet. This contact line has catenary suspension, there are two catenary suspensions arranged side by side, but is it necessary to discuss the question as to whether this works or does not?

In my opinion the question that should be discussed is the following: Is the arrangement of longitudinal catenary suspension preferable to simple transverse suspension or not?

It is not a question of knowing whether one kind or another of suspension will work, but of knowing which gives the best results, and from this point of view it is my impression that the whole question is being examined from too superficial an aspect.

The contact lines that are in actual service form a sufficiently large whole to enable definite comparisons to be drawn. Would it not be better to express the wish that the constructors of contact lines should make efforts to construct, for the tractor bows, a contact line which should in its general particulars be as perfect as that which the rails offer for carrying the vehicles? This problem may be solved in various ways according to the particular conditions caused by the traffic on the lines under consideration. With this object in view it would be almost certain that no inadequate contact lines would be installed.

The President. — It would be useful if members adhered to the general subject of paragraph 5, but this should not be regarded as deterring members from presenting useful general facts regarding overhead contact lines.

Mr. Gerard. (In French.) — Gentlemen, at the commencement of our meeting yesterday, the President asked whether any members desired to add other questions to those proposed by the special reporter. No immediate reply was given to this question and in the absence of such our programme could have been settled yesterday. To-day new questions are being put. I do not raise any objection, on the contrary I consider it better that the field of discussion should be enlarged and that data should be given with regard to the various systems concerned in the questions that have been given, without expression of opinion, in the list of questions.

With regard to Mr. Huber's point of view, it appears to me that he states : let the construction be good and we shall not have cause for anxiety to enquire which is the best. Let us try to obtain a good arrangement of suspension just as we have obtained a good construction of track.

Gentlemen, would not that be a summary procedure that would replace replies to the questions under discussion by a stereotyped phrase?

As the President has stated, the question has, I think, been put very shortly and very clearly and there are certainly some of the members here who are interested in investigating it more closely and giving us complete data.

Mr. Sabouret. (In French.) — I wish to draw attention to the fact that the question as it has been put, and in this respect it resembles the next question, in my opinion does not require the expression of a wish or of a vote. These are simply questions on which we exchange ideas. We are here as though we were in a mutual school, to which each of us brings the information which he has been able to collect personally and we benefit from the meeting by mutually teaching each other. But actually, we are not in the position to answer a question such as that which has been raised and to make a comparison between two systems of catenary suspension.

In the first place it would be necessary to define the systems. There are, actually, I do not know how many catenary systems, just as there are any number of transverse supporting systems. It would be necessary to commence by defining each class of support, and for each of these, by defining the system which is the best in order to arrive finally at a comparison of the best catenary system with the best transverse system. We shall thus express an opinion on present day practice. But who is to tell us that to-morrow, or the day after, some still better systems than these will not make their appearance?

I think, therefore, that it is quite impossible that we shall express a wish or pass a resolution of any kind on a question so wide as this is. Its discussion gives us the opportunity of exchanging views amongst ourselves, but that is all, and I think that we should keep within those limits.

It appears to me that the same applies to the questions that follow and also to some others that will certainly be put. I repeat we are here to exchange ideas which, of itself is a matter of great interest; but we have not assembled here to lay down laws. (*Applause.*)

Mr. Donati, *reporter*. (In Italian.) — I should like to make some remarks on the technical side of the question of longitudinal catenary suspension as compared with transverse suspension. The Italian railways have shown a preference for transverse suspension because it was thought that this satisfied the special conditions of our lines better from both the technical and the economic points of view.

The question was discussed at the time on a rather restricted field, because it was a question of the construction of suspension for the three-phase system, which, as is well known, requires two separate insulated conductors and a third conductor formed by the rails. It is obvious that, under these conditions, the arrangement of conductors requires certain special precautions that compel the adoption of arrangements specially suited to the end in view. It is for this reason that, on the Valtellina line, we began with the solution which appeared to us to be the simplest, that is to say that the two contact wires were completely insulated from each other and that, further, each one was carried by a special transverse suspension, because at that time it did not appear possible to insulate the lines suitably by means of porcelain insulators where they had a transverse connexion.

After the experience gained on the Valtelline line, steps were taken to improve the suspension and the idea was formed of making a single transverse suspension capable of carrying the two contact wires.

It was then decided to make a trial of the catenary suspension and on the line from Lecco to Calolzio a trial was made in which both systems were used.

This trial led to the following conclusions : for lines having many curves the spacing of the posts, determined by the necessary polygonal arrangement, being necessarily very close, the advantages of the catenary system are lost because the distance the poles are spaced apart depends on purely geometric considerations. It was then noticed that with this suspension it would not be impossible — and this is of the greatest importance — to arrange for the flexibility of the line to be maintained at constant value over the whole of the length, but that the simple catenary suspension could not meet these conditions, because it gave more rigidity at the points of attachment than at mid-distance between the poles. In the third place it was noticed that in the case of catenary suspension it was necessary to provide special automatic tension gear in order to maintain the contact wires in a position parallel with the track independently of variations of temperature.

Much doubt, however, has been thrown on the working of these arrangements, to such an extent that they have generally been given up, so that the contact wire, which is subjected to variations of temperature, ultimately ceases to be perfectly parallel to the rails. In regard to this parallelism of the contact line with the rails yet another point requires to be noted. If, by means of an automatic compensatory system it were actually possible to deal with the elongations due to temperature, or if by means of any other arrangements, no matter how complicated they might be, it were possible to obtain perfect parallelism between the contact wire and the rails, it would never be possible to make the action of the trolley perfect, because this takes its support from the roof of the auto-motor vehicle which itself is carried on springs that are subject to very irregular action arising from the rails. It has been found from calculations made on this subject that this cause gives rise to much greater variations than those that could be produced in the sag of the catenary suspension. If, on the other hand, the working of the trolley is considered, it will be found that it does not require that the line should be perfectly parallel, but merely that the movements of the bow should not be too jerky.

If, in fact, we suppose a conductor which is inclined continuously downward, we shall find that the bow can follow it perfectly; whereas the bow jumps, and sparks are produced, if a tendency to depress the bow is changed quickly to a tendency of the opposite kind.

Now, it can be definitely stated that this irregular movement depends nine times out of ten on the play of the springs rather than on the conditions of the line, because in the case of a well-laid track, and with conductor wires of adequate diameter, there are no changes of flexure at the points of attachment of the conductor wire so sudden that the trolley cannot follow them. Another improvement that has been made — and the reporters have only confirmed the results obtained on the Italian railways — is that of arranging — whatever may be the system of suspension adopted — a double contact wire in place of a single wire. Practice has shown the great advantage that is afforded by the division of the contact wire into two conductors, over the single wire of double section.

This system shows a great advantage with regard to taking the current, not only because there are two points of contact for each bow, but because the bow is kept more steady while running. On the line from Turin to Pignerol we have made a special trial of laying one wire first and subsequently adding a second wire; these trials have afforded proof that whereas with the single contact wire a fairly regular supply of current is assured — but not very regular because some wear occurred in the conductors — this wear was, on the other hand, greatly reduced by the arrangement of two wires. The current was then taken without any sparking.

This is the reason why on all the Italian lines — and the Valtellina line even has been rearranged in this respect — two conductors are used instead of a single conductor. Of course, in speaking of the contact wire, I mean the contact wire for each phase, that is to say four wires in the case of a three-phase current.

Another great advantage is found by increasing the diameter of the wires within certain limits. Experiments have been made with wires 8 mm. (0.315 inch) diameter; that is to say 50 mm^2 (0.0775 square inch) in section and with wires 11.33 mm. (0.446 inch) diameter; 100 mm^2 (0.155 square inch) in section. Now the conditions under which the wire 100 mm^2 in section is worked are not only enormously superior to those of the wire of 50 mm^2, but with a wire of 100 mm^2 the influence of the points of suspension was no longer felt, because the rigidity of the wire at the points of suspension as well as at the lowest points of the catenaries was sufficient to prevent the trolley from being subjected to appreciable variation both at the point of suspension and at the lowest point of the catenary.

Another great advantage is due to mechanical reasons. Whereas with a wire 8 mm. (0.315 inch) diameter the breakage of a trolley may sometimes involve the breaking of the contact wire and the fall of the line, with subsequent disturbance to the working, with wires 11.33 mm. (0.446 inch) diameter the breakage of the trolley never causes breakage of the contact wire and the conductor line remains intact.

This is the reason which explains why, on the Italian railways, notwithstanding the adoption of the three-phase system of which the contact lines are doubtless more complicated than those of the other systems, it has been possible to obtain perfect working of the overhead lines in practice. For example in the Turin Division, which represents the lines from Turin to Modane and from Turin to Pignerol (and also the line from Turin to Chieri) it has been found that delays due to the contact line amount only to 80 minutes per month for the whole of the trains (and there are 40 trains per day), against a total of 2 000 minutes delay monthly due to other causes, for example to the electric locomotives.

The contact line has consequently attained a degree of perfection capable of ensuring regularity of working.

If we now consider from the economic point of view whether the wire with longitudinal catenary suspension is more suitable than that having transverse suspension, I think that, as Mr. Sabouret very wisely remarked just now, the question is at any rate premature; there is no need to attempt to obtain an absolute solution, applicable to all cases; but, on the other hand, every case should be considered with a view to finding the most suitable system.

If we take the case of a line having a number of tunnels and many curves, I maintain that, in this case, transverse suspension is the most economical, because obviously longitudinal catenary suspension could only be used with great difficulty in the tunnels whether built to the Italian gauge or to that of other European railways. Owing to the fact that the support must be obtained from the roof of the tunnel, there would be no advantage in adding a longitudinal wire to carry the contact wire, even if it were possible to instal it. It should be noted that on curves the spacing of the poles or supports is determined by the necessary polygonal arrangement of the contact line, an arrangement which itself depends upon the available width of the collector bows.

It is possible that, under special conditions, on straight lines where the single phase or continuous current has been adopted, longitudinal catenary suspension may be suitable, but it is also necessary to take into account the cost of materials.

In Italy where metallic materials, and particularly steel cables, are so dear at the present time, catenary suspension cannot compete successfully with transverse suspension particularly when special circumstances require to be taken into consideration, such as the presence of tunnels and of numerous curves as has just been mentioned.

Another condition which must also be considered when making the choice of the suspension system, is the question of safety and of maintenance. I think that for contact lines it is absolutely necessary to adopt very solid methods of construction, because any economy effected in construction is subsequently paid for very dearly by the greater cost of maintenance.

We have, in fact, the example that on contact lines constructed with a wire of large diameter — 100 mm^2 (0.155 square inch) in section — of double V form it has been possible — and this has been confirmed also by Mr. Semenza according to the trial made on the Chicago-Milwaukee & St. Paul line — to ensure the maintenance of sections of lines ranging from 19 to 22 miles in length with a very small staff, whereas on lines of light construction or not so soundly arranged, if economy is effected in the installation, the cost of maintenance becomes higher and may even rise till it absorbs the saving effected by the economy made in cost of installation. (*Great applause.*)

Mr. Lanino. (In Italian.) — Mr. Donati has clearly shown that from the technical point of view all the existing requirements of railway service are completely and perfectly satisfied by the conductor with transverse suspension and, by implication, by the line with two conductors, as required for the three-phase system.

Now the question as raised by Mr. Gerard is, according to the careful statement of Mr. Sabouret, quite general in its application.

It is asked : is longitudinal catenary suspension preferable to transverse suspension or not?

We once more fall into the discussion of the same technical problem as that we found ourselves engaged on just now when we asked ourselves which type of current should be selected; we then agreed to state that no absolute categorical reply was possible. For if we consider the problem of the conductor line from the abstract point of view, I should myself admit, as a convinced partisan of the three-phase system and perhaps the oldest of that opinion, that the longitudinal catenary system, is that which ought best to satisfy all the technical requirements, even when compared with transverse suspension, particularly for high speeds and it is that which should show the greatest economy in cost of installation. But, if this is true from the abstract point of view, it is not so true in the concrete instance. When, twenty-five years ago in the Valtellina, the problem was considered for the first time, catenary suspension had not come into existence.

The only method available was transverse suspension, which came to us through tramways, and the third rail system used on suburban railways. In Germany trials had been made which many of you will recall : those on the well-known line from Berlin to Marienfeld, three-phase, lateral, with appliances for taking the current at the side, but this was the only one; in the Valtellina transverse suspension was therefore adopted because it was the only kind that had been used in practice and this system on the Valtellina was subsequently introduced on the large State railway system on which transverse suspension appeared to be necessary for the three-phase system.

Now if as general rule it may be taken that longitudinal catenary suspension is equally suitable, and even in some respects more suitable than transverse suspension, both from the technical and economic points of view, this does not mean that it can in all cases be substituted for transverse suspension in railway traction; nor does it mean that because the three-phase system implies the use of transverse suspension, this system should therefore be excluded.

For the problem of electric traction — and in these matters perhaps I am somewhat exceeding the limit within which the discussion of the fifth paragraph of the conclusions of the special reporter should be kept — does not only consist of the problem of the conductor wire; we must, on the other hand, consider the line and the locomotor vehicle together and, in some cases — and this is the case which concerns us most on the Italian railways — it is the problem of the electric locomotive that predominates over the problem of the conductor wire, particularly so far as economy is concerned.

Electric traction is used at the present time in Italy and will be, in my opinion, for a long time to come, and since the commencement, twenty-five years ago, it has been used to solve the problem of mountain railways and of trunk lines by means of a rapid service. It is for this reason that the principal problem is that of the electric locomotive, that is to say the problem of a motor capable of giving the maximum tractive effort with the minimum weight of locomotive.

It is a problem which seems to be of technical character while it is essentially of an economic character, because in dealing with the problem on the trunk lines we could have avoided the construction of new lines by increasing the capacity of the existing lines.

Now these trunk lines are principally lines of short length and carrying very heavy traffic. It is for this reason that it would matter little that the line fitted with the longitudinal system of suspension for three-phase traffic should cost even double as much as a line fitted with the catenary suspension system for single phase or continuous current. In fact, the point of interest here is to obtain an electric locomotive suitable to the requirements of the traffic, and it is recognized by all those who are competent to judge that our electric locomotive of the 050 class is at the present day, one which gives the maximum tractive effort with full utilization of adhesion whether steam or electric locomotives are under consideration. Moreover, in Italy the track rails are light, the curves are numerous, there are reverse curves and short lengths of straight between the curves, conditions which make the problem of the construction of the electric locomotive very difficult, and when it is the electric locomotive that is the primary factor in a traction problem, the problem of the overhead conductor takes a second place. This problem cannot be solved by stating that longitudinal catenary suspension is better than transverse suspension; the problem must be solved elsewhere.

If, on the other hand, we go to lines with great lengths of straight track, carrying light or comparatively light traffic, then the problem of the overhead conductor and particularly that of its expense is the predominating factor; the exigencies of traction do not make themselves felt and it is possible for us to state — I, who am an avowed adherent of the three-phase system, as well as others — that longitudinal catenary suspension is preferable to the transverse system.

The problem of electric traction at high speeds by means of overhead conductors is, as you all know and as you all feel, not a traction problem but a superstructure problem involving the signals, etc. But, perhaps, in investigating this problem — and I say perhaps because I cannot speak from actual experience — you might find that the longitudinal catenary suspension would give better results than the transverse suspension for very high speeds. Perhaps, also, on account of the dropping of the collector which may occur near the contact points on account of the speed, it might be necessary to have recourse to a third type of suspension for extremely high speeds. I should be extremely glad to see that three systems of suspension, instead of two, were under consideration at the next Congress. As the result of a long process of evolution extending over twenty-five years, accomplished in Italy at the cost of continual and persevering effort and by uninterrupted work, it has now become certain that the three-phase conductor system with transverse suspension has obtained such results that from the technical point of view it may be considered perfect. The managers of the Italian railway Administrations have therefore reason to say : Before making any change we must know how to make it. If we are to make a change, we should like to be certain of arriving at a better result; if we find that the new systems give greater safety than the system that we have adopted, then we will make the change.

Our divine poet Dante Alighieri has said :

Ogni permut aura credi stolta
Se la cosa dimessa in la sorpresa
Come il quattro nel sei non è raccolta.

(*Think false all that which is new, unless it is contained in that which you leave, just as the four is contained within the six.*)

When we can be sure of obtaining such an advantage by making a change then shall we associate ourselves with that change. (*Approval.*)

Mr. Sayers. — I should like to make a few remarks on the question already mentioned of the elimination of hard points in the contact lines.

The experiments made on the Midland Railway on a line 9 miles of double track operated by single phase traction show that next to the insulation the elimination of hard spots is the point to be considered in the construction of the line. The best way to eliminate these hard points is to multiply the number of suspension points, and this clearly implies the use of catenary suspension.

I have been trying for a period of three years a piece of this line 3 miles long erected in such a way as to avoid even pull-offs for holding the contact wire steady as I recognise that these pull-offs with their necessary extra weight on the contact wire at one point constitute a hard running point to the bow. The improvement is obtained by crossing the catenary cable from side to side of the centre line, the contact wire being thus not only suspended but held from both sides of its longitudinal axis in each span.

The choice of longitudinal suspension versus transverse must depend upon the nature of the traffic, and with speeds of 70 miles an hour with heavy trains (that is such traffic as we get on the main line in England) there can I think be no question of putting up any other construction but the catenary system with multiple suspension points.

Another point of less importance has a considerable value in design, and that is the maximum gradient in the vertical plane which should be given to the contact wire when for instance it has to pass under a bridge. We have found on the Midland line mentioned above that a gradient of one in one hundred will give satisfactory results and keep the bow always on the contact wire for any speed up to 70 miles an hour. The vertical pressure given to the bow throughout its range on our line is about 10 lb.

Mr. Semenza. (In French.) — It must not be forgotten, for clearness of discussion, that on account of the points the three-phase electric locomotives always run with two collector bows so arranged that the bow, which passes the suspension point, is shunted by the other. This explains why the transverse suspension line does not give rise to sparking.

The President. — Experience in America indicates it is not possible to produce a wholly successful overhead contact wire system for heavy electric traction on trunk line railways unless the vertical catenary suspension method should be employed. I mean, for railways having the complicated track conditions, switching connections, yards, terminal, etc., found on the important railways, and high speed and dense traffic with heavy trains. Electric traction installations cost a great deal of money, and no pains and expense is spared to obtain the best electrical apparatus and safeguards in the power supply. Why, then, should we try to save a little first cost in the contact system by adopting inferior devices, when it is essential for the success of the entire installation that current shall be reliably conveyed to and collected at the trains?

As we have but a short time remaining for discussion of question No. VIII by the section, I beg that the reporters upon this question remain after the sitting is adjourned in order to formulate the wording of the recommendations to present for action at the next session.

Mr. Donati. (In French.) — I should like merely to add that with the transverse suspension adopted on the Italian railways there are no hard spots in the suspension and it is possible to run perfectly up to speeds 62 miles per hour.

The President. — I put paragraph 6 for discussion :

Has the use of three-phase current at 50 periods given rise to practical results justifying its extended use for main line railways ?

Mr. Gerard, *special reporter*. (In French.) — I think that this question has been dealt with in one of the reports. It is stated that investigations are in progress concerning the possibility of using greater periodicity in the application of three-phase current to traction.

In this connection I would ask the President for authority to introduce a small extra point. If rather greater periodicity is desired in the use of three-phase current motors it would be with a view to the simultaneous use of this current for traction, for motive power, and for lighting. I have taken the opportunity, in this connexion, of handing round copies of the paper that I gave to the Belgian Society of Electricians concerning the use of a three-phase lamp containing three wires in the bulb, and thus concentrating the three phases and avoiding the disadvantages of electric polyphase lighting, disadvantages which make themselves felt when the periodicity is very low. I can speak of it the more freely as I am quite a disinterested party; I have learnt that my patent has been anticipated thanks to the efforts of Werner Siemens and Thomson-Houston who have rather flattered me by their anticipation. There can therefore be no incompatibility between lighting and traction by three-phase current of low periodicity.

The President. — Will not some representative of the Italian railways favor us with a discussion upon this subject, based upon his experience with the use of three-phase current at 50 periods?

Mr. Lanino. (In Italian.) — With regard to the question of the industrial frequency of 50 periods, it is worth considering that although such installations do not exist on the large railway systems, there are, however, tramway and suburban railway installations that are worked with this frequency.

In Switzerland there is the line from Berthoud to Thun constructed earlier than the Valtellina. We have some tramway installations in Milan, and a small railway near Rome for working the quarries between Tivoli and Bagni di Tivoli constructed by the « Tecnomasio italiano » and worked at 42 periods. From my position as technical consulting engineer of the « Tecnomasio », which is actually the Italian Brown Boveri, I know that an electric locomotive for 50 periods, intended for the State railways, is now being designed and I think that there are also other Italian undertakings that are designing high-power locomotives to run at 50 periods.

Mr. Donati. (In French.) — In the first place I confirm what Mr. Lanino has said. I will add that the Italian railways have investigated and are at the present time engaged in arranging for the electrification of the Rome-Tivoli and Rome-Carano-Anzio-Nettuno lines, having a total length of about 62 miles with three-phase current at 45 periods and electric locomotives of about 3 000 H. P. The construction will be carried out by Italian firms, that is to say by the « Tecnomasio italiano » Brown-Boveri, by the Breda works and by those at Saronno near the lake Maggiore.

The voltage on the contact line will be 6 000 volts. It will be possible to obtain 10 000 volts by connecting the secondary windings of the transformers in star instead of connecting them in delta.

In Spain there is a short line 13.7 miles long worked at 5 200 volts. If my recollection is correct it runs, I think, at a periodicity of 45 periods. Perhaps some member may be present who can confirm these particulars.

A Delegate. (In French.) — The line works at 25 periods and at 5 500 volts.

Mr. Huber, *reporter*. (In French.) — Gentlemen, I am in the position to be able to inform you about the experiment with three-phase traction at 42 periods made on the Berthoud-Thun line. The current is supplied by the Bernese Motive-power Supply Company. On various occasions an endeavour has been made to connect the feeding line of this railway to the general supply system, but these trials have not been successful. The conditions under which this three-phase current line took its energy disturbed the adjustment of the general supply system of the Motive-power Supply Company to such an extent that it was necessary to return to feeding this line separately from the rest of the system.

I quote this fact to show that, even when the so-called industrial periodicity is adopted, which in Switzerland is either 50 or 42 periods, it is not possible to connect the supply of the railways to the general supply system, as would be desirable.

I might also quote other examples — but in these it would only be a question of schemes that had not been carried out — of current supply companies who were unwilling to combine railway supply with the general supply on account of the trouble which would have been caused in the regulation of the general system.

Mr. Semenza. — I should like to know whether, when Mr. Huber speaks of the connexion between the railway service and the industrial service he talks of a connexion established by transformers alone or whether he means by this that the connexions are made through rotary machines.

Mr. Huber. — When I speak of the connexions between a railway and a general supply system, I am speaking of the simple connexion with or without transformers to the bus-bars of the central station. When rotary converters are used it is obvious that considerable independence of working between the two systems is obtained, but at the same time the greatest economic advantage, dependent on the utilization of currents having the industrial frequency, is lost. I can quite believe that the use of currents of high periodicity for the electric working of railways promises to be economical, and it appears that it may be quite possible, but in order that this solution may be advantageous it must not be necessary to have recourse to rotary converters.

Mr. Parodi. — I have examined the installations of which Mr. Huber has spoken with one of the Company's engineers. I have been shown that the power factors of the Berthoud-Thun (Burgdorf-Thun) line are exactly the same if not better than those of the Loetschberg single monophase line. I do not, therefore, understand at all why this installation, which is of quite small power compared with that of the Loetschberg, should cause trouble in the service to the factories whereas that of the Loetschberg does not cause trouble. (*Interruption.*)

Moreover, I do not remember having seen in the Spiez works three sets of bus-bars; I only saw two. If there are only two it would be very interesting to know how the Berthoud-Thun line can be supplied separately.

Mr. Huber. (In French.) — The question of the power-factor has not much to do with the case. It is the sudden demands for energy by the railway that upset the voltage of the system and it is for this reason that it is always necessary to separate the railway service as much as possible from the general system.

Mr. Parodi. (In French.) — It is, however, only a small thing compared with what the Loetschberg locomotives take.

Mr. Huber. (In French.) — This does not prevent the trouble from occurring.

So far as the Loetschberg railway is concerned, let me state once more that it has nothing to do with the question. It is an entirely separate service and, moreover, a single-phase service is not a three-phase service.

Mr. Donati. (In French.) — I ought to remark that, in order to have a common service for traction and lighting, it is necessary that the governor of the turbines and the automatic governor of the voltage should be of the latest modern and practical designs. This is not the case in the supply of the Berthoud-Thun line. The supply is provided by machines that are now out of date and are not arranged to satisfy these very difficult conditions. It is possible now to work with a 50-period current in such manner as to have a common service for traction and lighting without any interference between the two loads.

Mr. Parodi. (In French.) — This is a question of the ratio of power supplied to each of the two services.

Mr. Huber. (In French.) — I do not say that the thing cannot be done, but in this case, it is necessary, in the present state of our knowledge, to arrange that the ratio between the energy supplied to the railway and the energy of the industrial system should not exceed a certain value which is not indeterminate; and if one can join a small branch line of railways directly to a large industrial system this certainly does not mean that it would be possible to connect a line carrying heavy traffic with an industrial system of not very great magnitude.

Mr. Parodi. (In French.) — That is what I wish to say : the thing is possible. From my point of view, the example of the Berthoud-Thun line does not prove anything at all and should not be taken into consideration.

Mr. Lanino. (In Italian.) — I should like to draw to the attention of the meeting to the fact that this question of three-phase traction at industrial frequency is a question of the future and I should like to invite the Congress to consider that this is not a question that can be passed over lightly. It is, on the other hand, of very great importance, particularly in countries having small railway development and especially small electrical development, but which, nevertheless, require to transmit energy to a great distance. I speak for these countries and in particular for Southern Italy. It is necessary in this region — in the interest of the Nation rather than that of the contractors who are concerned in the production of energy or of the consumers of industrial and motive power, and I rely on what I said yesterday — it is necessary, I said, to make the power generating system, the power distribution system, and the utilization of the current as economical as possible.

Now this differentiation of electric traction from other forms of utilization of energy, having its special type of current, its own central stations and its own distribution system, sometimes leads to so great a cost of installation as to constitute a debit for the National Treasury.

Now if the problem of traction by three-phase current of the industrial type could be solved suitably — and in this respect I would go back to the remarks made by Mr. Donati, because (the data relating to the Berthoud-Thun line can not be considered as having any weight) it can be affirmed that the problem has not yet been solved — and consequently if it were possible to use the industrial supply current, which in our country is at 42 to 50 periods, a great step forward would be taken to render electric traction more economical.

The President. — Seeing the lateness of the hour, I propose that we debate very briefly on paragraph 8 :

8. — Is multitraction more suitable with one type of current than another?

Sir Henry Fowler asked that a clear definition should be given of the meaning of the word multitraction.

Mr. Gerard. (In French.) — The term multi-traction was used by Mr. Sabouret to mean the use of several locomotives for the traction of a single train.

The President. — I find that we are in agreement in considering that paragraph 8 has solely in view the use of two or more locomotives for hauling on train.

Mr. Sabouret (In French.) — Gentlemen, I am going to put a question which may appear to you not to refer directly to paragraph 8, but which has, however, some connexion with it.

In the report of Mr. Gibbs for America, it is stated that the Westinghouse system of single phase traction used in the United States is a complete system that meets all requirements, and solves all difficulties. Now, in the same report, we read that on the Norfolk & Western Railway when it is a question of hauling trains of 3 000 and 4 000 tons on gradients of 20 per mil and on a line having closely following traffic, the Company, instead of being satisfied with the simple single phase current has complicated the system by adopting the combination known as the split-phase. I should like to know what are the reasons that have caused them to abandon the simplicity of the ordinary single phase in favour of a system having very great complication from which I believe it has not yet entirely emerged. I have found no explanation of this matter in the report relating to the United States and I hope some information may be given to us on the subject.

The President. — I would, in replying to Mr. Sabouret's question, point out that there is no electric system called the « Westinghouse » or the « General Electric »; we know systems by their technical characteristics — not by the names of Manufacturing Companies. Moreover, no company has a proprietary right to any system.

Now, as to the reasons for using the mono-three phase system on the Norfolk & Western Railway. The installation was one for special conditions — a complete « gathering » division for a dense traffic in the coal mining dictrict on a line comprising heavy-grade operation over the Alleghany Mountains. The trains were heavy, 3 200 tons trailing load on a 2 % grade. A pusher locomotive in addition to a head engine, was necessary for capacity and safety and, because of the difficulty in co-ordinating the starting of two locomotives nearly one-half mile apart on a very crooked road, it was desirable to adopt a motor which would exert torque for a considerable length of time standing. Furthermore, automatic recuperation of energy in descending the grade was important; also uniform running speed for the trains. All of these requirements are best and most simply met by use of the three-phase motor. As, however, two separate trolley-wires required for the straight three-phase system were considered inadvisable under the local conditions, the single-phase trolley was adopted with a « phase-splitter » mounted on the locomotive, to furnish current of the phase characteristics suitable for the three-phase motors. The system was never regarded as an « universal » one — it is special and for special cases; it is an illustration of the inherent flexibility of the « single-phase » system, which allows either single-phase or three-phase motors to be employed in the same line.

Mr. Huber. — Gentlemen, I can tell you in the very clearest manner that in Switzerland, with single phase traction, we do not find any difficulty arising from multi-traction. On the St. Gothard line which is certainly one of the most difficult lines in Europe from every point of view, we are able to use double-heading whenever necessary without any difficulties. We have locomotives taking single phase current direct because, in our small country, we cannot afford to go a long way round. We have no locomotives with converters. The difficulty therefore does not exist and that is the reason why we have not mentioned it. We couple the single phase locomotives together with the same ease as steam locomotives.

Mr. Parodi. — I should like Mr. Huber to tell us whether, in the case where, in Switzerland, single phase current at 25 periods has been used instead of at 15 periods he thinks that the same could have been done.

Mr. Huber. — I think that without appearing impolite I may refrain from answering Mr. Parodi's question. In my opinion, the reply to this question could only be given as the result of actual experience obtained, and I am obviously not in a position to make experiments with what I do not possess.

In Switzerland we have adopted the periodicity which is probably the best for the system that we have applied and we are very pleased to have made so much progress. The question of knowing whether another system could be used simultaneously with this has not arisen in our case, and I think that Switzerland is rather to be congratulated on the position she occupies in this respect.

The President. — Is the section of the opinion that the discussion of paragraph 8 should be continued Monday morning? The members who desire to present to further observations on this paragraph are requested to be good enough to make themselves known.

Mr. Donati. (In French.) — I think certainly that it would be better to continue the discussion on paragraph 8 on Monday morning.

Sir Henry Fowler. — I propose that the discussion on question VIII be closed, and that Monday morning we start the discussion of question V : « Economic production and use of steam on locomotives. »

The President. — I think if the discussion should be pursued on question VIII, it would be preferable to resume it Monday morning.

Mr. Huber. — It appears to me that it would be possible if necessary to hold a meeting this afternoon.

— The proposal made by Sir Henry Fowler, was put to the vote, but was not carried.

Motion of procedure.

Mr. Van Loenen Martinet. (In French.) — Gentlemen, will you allow me to speak on a subject which has nothing to do with the matters on the agenda.

To-day is a public holiday in Italy and particularly in the City of Rome : Rome was founded 2 675 years ago to-day.

This session has up to the present been one of heavy work. We have however been able to form a slight idea of the wonderful monuments contained in this beautiful city and we have in any event been able to appreciate the great hospitality shown to us by the city of Rome and by the Italian Nation.

I propose, gentlemen, that we take this opportunity for offering our sincere congratulations and heartfelt thanks to the city of Rome and to the representatives of the Italian Nation who are here present. (*Loud applause.*)

Meeting held on 24 April 1922 (morning).

MR. G. GIBBS, PRESIDENT, IN THE CHAIR.

The President. — It is necessary to restrict, if possible, the discussion of the question of electric traction, as our time is short. I therefore propose to limit the time of speakers, and to terminate the discussion at 11 o'clock. (*Assent.*)

I propose besides at 11 o'clock to take up again discussion of the question : « Economic production and use of steam on locomotives. (*Fresh assent.*)

Finally, I propose to hold a joint sitting to-morrow with the 3rd section in order to discuss question XII : « Locomotive cab signals. » (*Assented to.*)

We will now follow this procedure.

Since our last sitting, the reporters have drawn up the conclusions on question VIII, — as follows :

« 1° The Congress recognizes that at present a single system would not be recommended for all cases any more than in the past, nor is it possible to choose between several systems, all of which have proved their value under the most severe conditions of operation; the Congress recognises, moreover, that these systems are all susceptible of considerable further improvements;

« 2° The Congress agrees on the uselessness of standardisation of the type or pressure of current in the contact wire on account of the ease with which locomotives may be changed at the frontiers of the different countries;

« 3° It is desirable that the methods of keeping and supplying technical and economical information on electric traction should be defined and standardised, and with this in view, the section suggests that this point be referred to a special committee of the Association. This committee should draw up very fully the details governing each point so that in future as full a comparison as possible may be made by means of figures absolutely comparable. »

— If there are no objections to these conclusions, a vote on their adoption is in order. (*On motion, adopted.*)

The President. — We have still some time left for further discussion of matters pertinent to question VIII, for instance, « the use of high-tension direct current for motors on cars »; also, that of « inductive disturbances in telephone and telegraph lines from electric traction currents ».

I will call upon Mr. Sabouret to speak.

Mr. Sabouret. (In French.) — I should like to say a few words on a question that relates to the 4th question dealt with by Mr. Gerard : that is the question of multi-traction; and I should like to ask for some particulars from our Swiss and Italian colleagues with regard to this.

I find, in fact, in the very interesting reports that have been submitted to us, an apparent contradiction which I should like to see cleared up.

The Italian reporter states that the adhesive weight of electric locomotives for hauling goods trains has been limited to 60 tonnes, and that this limitation is determined by the strength of the couplings. The whole of the Italian organization depends on this detail and we do not hesitate to use a second locomotive at the rear of the train when we have to haul very heavy loads up steep gradients. This method of traction may therefore be said to be normal on the Italian Railway System. Now I notice in the Swiss report, that in Switzerland the adhesive weight is as high as 108 tonnes. The trains nevertheless consist of exactly the same vehicles in Switzerland and in Italy. I am therefore at a loss to understand how these two contradictory statements can be reconciled.

Mr. Huber. (In French.) — It is well known that in Switzerland as in Europe generally the strength of the couplings is not very great and we can look upon the Americans with envy because they have much stronger couplings.

At the commencement of the electrification of the Swiss railways we confined ourselves to a tractive effort of 10 tonnes. Little by little we increased this figure, because in the case of the passenger stock the couplings were very much stronger, and we increased the pull in the first instance to 12.5 tonnes and subsequently to 15 tonnes.

With regard to the locomotives of goods trains, we have refrained from using them on heavy gradients to the extent we have done for the passenger trains. Actually we are already using much greater drawbar pulls than we did a short time ago.

Our programme for traction on the St. Gothard line comprises the scheme for hauling trains consisting of 400 tonnes of vehicles attached to a locomotive on gradients as severe as 26 to 27 per mil; we intend moreover to run goods trains weighing 800 tonnes with one locomotive at the head and one at the tail. I cannot say from memory whether the figures of 60 and 108 tonnes actually agree with the 10 tonnes at the draw-bar. We are perhaps not quite in agreement on this point with the other authorities who are entrusted with framing the regulations on this subject, which regulations will be definitely accepted sooner or later after they have come into use! Mr. Weiss will perhaps explain to us the reasons why the figures which were considered suitable at one time must not now be taken as absolutely accurate. It is evident that progress must be made.

Mr. Donati, *reporter*. (In French.) — The limit of 10 tonnes was imposed on us by the fact that in Europe the rolling stock is not fitted with couplings of sufficient strength. On the Italian State Railways the normal tractive effort at the draw-bar was taken as being 10 tonnes. On passenger trains however, it reaches 15 tonnes. We have found that, with an adhesive weight of 60 tonnes, it was possible to obtain a coefficient of adhesion of one-fourth. When these limits must be exceeded, particularly in starting, it is necessary to adopt double hauling with one locomotive at the head and one at the tail; and if this is not sufficient triple hauling is used, that is to say one locomotive at the head and two in the rear.

Mr. Semenza. (In French.) — I proposed to add to the questions which had been set forth by the President, that of the transmission of power from the motors to the wheels in electric locomotives; this relates to question No. 7, treated by Mr. Gerard, which has not been discussed. I think that this point is a very important one.

The President. — Whilst Mr. Semenza's suggestions are of great interest, I believe we should first finish the discussion of the points already proposed, taking up his points later. One of these is the question of the use of high voltage direct current motors. In this connection I refer to a practice which we have found advisable in suburban services in America to make each car in the train a motor-car. This practice adds greatly to the flexibility of train make-up at terminals and avoids much shunting which would be necessary where trailer cars are used. The point has a bearing upon the maximum permissible trolley voltage for direct current system, inasmuch as no motor-car equipments for 3 000 volts are yet in use in America. I should be happy to hear the opinion of members as to the advisibility of using 3 000 volts on the trolley for multiple unit train services.

Mr. Japiot, Paris, Lyons and Mediterranean Railway. (In French.) — I have not quite understood why the President has stated that the only way of avoiding shunting operations at a station is to use automotor vehicles exclusively. It appears to me that if there are a sufficient number of these vehicles to enable the trains to be made up according to the amount of traffic, the problem can be solved as readily and at less expense than if automotor vehicles are used exclusively. For example if all the trains are made up alike, it is only necessary to have one automotor vehicle (or one automotor van) at the head and at the tail, for running backwards and forwards which does away with all shunting in the station approach. If at certain times of day only one half of this length of train were required, it will be sufficient to arrange two automotor vehicles in the centre and one at each end in order to solve the problem without being tied to the exclusive use of automotor vehicles.

The President. — In my opinion, in an extremely congested suburban service all unnecessary shunting should be avoided so that when a train is composed of a certain number of carriages at the hours of little traffic, two or three carriages should be simply left at the platform. Hence there is a decided advantage in composing all trains of automotor carriages exclusively.

Mr. Duer. — It is very useful in electrical systems employing motor cars to have each car equipped with motors. One of the considerations which make this desirable is the fact that terminal stations do not always have sufficient tracks to take care of storing cars. Therefore, when a certain number of cars are detached from a train, those remaining in service must preserve the same proportion of motor cars to trailer cars and the cars which are cut off must have the proper number of motor cars to trailers, in order to move to the storage and cleaning yards. Furthermore, the employees charged with breaking up a train are not always experienced enough to assign the proper number of motor cars and trailer cars to each train, so that the motors will not be overloaded by a too great proportion of trailers. Finally, I would say that the cost of equipping motor carriages for the same weight of train does not appear to me to be sufficiently great to exclude the use of a system where all the cars are equipped with motors and which presents the advantages I have explained.

The President. — Is there no delegate present who can inform the meeting as to European practice in the make-up of suburban service trains? That is, are trains of motor-cars exclusively, or motors and trailers?

Mr. Parodi. (In French.) — In the early installations for suburban trains the idea had been to use nothing but automotor vehicles for the service. This has been done in particular on the Western-State Railway (Ouest-Etat). Since then it has been found that the service could be worked just as well by using units consisting of one automotor vehicle and one or two trailers.

The same arrangement will be adopted on the Paris-Orleans Railway.

Mr. Donati. (In French.) — On the Milan-Varese Railway there is a system which is almost identical with that mentioned by Mr. Parodi. It is proposed shortly to put into service trains consisting of one automotor vehicle, one or two trailers, and lastly an automotor vehicle. In sidings it is not necessary to change the arrangement of make-up of the trains. The method that has been followed has given complete satisfaction.

The President. — If there is no further discussion, we will take up the next point : « Inductive effects in lines of communication. »

I call on Mr. Huber.

Mr. Huber. (In French.) — This subject comprises a large number of special characteristics and I shall be obliged to deal with it in a very summary manner.

The disturbances, caused by some of traction currents, in installations using weak currents have given rise to a great deal of criticism. There are not, I think, many questions within the province of electrification, that have given rise to so much investigation and to so much misunderstanding.

When a railway Administration and a telegraph and telephone Administration exist side by side there may be a spirit of co-operation between the two, but there may also be the contrary. Then difficulties begin to arise.

I must state however that in Switzerland the Railway Administration and the Telegraph Administration have not been very greatly disturbed by the difficulties that arise from the use of electric traction.

Any measure that is intended to meet the difficulty costs money and the whole question is, in brief, to know on whom the expense should fall. In my opinion it should be shared. If, there exists laws or customs that determine the proportion according to which the expenses are to be divided, the main difficulty is solved.

I cannot state offhand the amount of expenditure in francs and centimes. I will confine myself to stating that the question of knowing who should pay does not concern us greatly in Switzerland. Our Administration of telegraphs and telephones, which is Federal, and the Administration of the Federal Railways work in perfect agreement and we can only say that the first named has taken the opportunity that was offered to it to reconstruct its system where it came close alongside electric-traction lines, by increasing the number of wires and the capacity and quality of the installations and by replacing overhead wires by cables.

The President. — While I have given this matter much consideration for a number of years, I have no intention of taking up the time of the meeting by entering into the discussion of highly technical details. The point of real importance, I think, which we should bring out is the necessity of co-operation between interested parties in mitigating inductive effects; we should not allow the presence of these effects to scare us off from the development and use of desirable electric systems; we must have the best system if electric traction is to extend greatly. I can remember the cry which went up from the telegraph and telephone companies when the first city trolley line was put in operation in the City of Richmond, Virginia; the earth return currents promptly put out of business the grounded return circuits of the telephones. The telephone company attempted to enjoin the trolley company from operating its road. The matter was settled by both companies improving their lines. Now, the case is somewhat similar; the telegraph and telephone companies wish to discourage the use of alternating current systems; they should not be allowed to succeed in doing so. The two interests should get together, each doing what is possible to remove defects and modernize apparatus. The situation is not at all hopeless; the remedies are indicated and the expense to both parties in applying them is not prohibitive, considering the benefits to be obtained — benefits which are not all on one side, either. The telephone companies and the alternating current railways are living together in America under, in some cases, very difficult situations; further improvements are not only possible but are at hand. I shall be happy to hear the opinions of other delegates upon the subject.

Mr. Bachellery, French Midi Railway. (In French.) — The question of the influence of the traction currents on the telegraph and telephone lines is one of those with regard to which the Midi Company has had to take special measures for about twelve years during which trials were in progress with single phase traction.

From the commencement the induction effects were rather large and showed themselves on the telegraph and telephone lines and we were obliged to find methods for checking these disturbing effects. We carried out very extensive researches. We were not able to imitate our Swiss colleagues who adopted the radical solution of moving the telegraph lines away from the railway, but, while leaving the telegraph and telephone lines arranged alongside the tracks, we sought to reduce the effects of induction. I think it will be necessary to go to the United States to find as complete a set of researches as those which were made on the French Midi Railway. On lines carrying a large amount of traffic, such as the line from Perpignan to Villefranche, we succeeded in obtaining useful results, but they involved the use of somewhat complicated arrangements. We were forced to make use of « suction » transformers arranged about every 2.5 miles, which instead of allowing the return current to flow through the rails, sent it back through the return feeder carried on the same supports as the contact wire.

But even this was not sufficient. The electro-magnetic effects were no doubt eliminated, but the electro-static effects remained and we were obliged to eliminate these by means of a wire of opposite voltage, through which current, out of phase by 180° in respect to the traction current, was passed.

By means of the superposition of these two arrangements we have succeeded in practically eliminating the disturbances, and the result has been that the effect of the traction current on the telegraph and on the telephone has been completely overcome. This has followed a joint inquiry carried on for several years between the railway and telegraph representatives. We have, moreover, obtained a check on this because, when one or the other of our two protective arrangements has happened, by accident, to be put out of action, the disturbances have recommenced and we have received complaints from the telegraph service.

We can therefore assert that we have found a technical solution.

This solution, however, is costly. I should add that the line from Perpignan to Villefranche is unfavourably situated, because a length of 31 miles is fed in one length and from one end only. If we had continued to use single phase current on the Midi System, it is probable that we should have endeavoured to improve these conditions by bringing the feeding points closer together. This is the solution which has been adopted in the United States, in particular, where the feeding points are arranged at distances of 3 miles apart.

We have not continued these investigations because the Midi Company have now abandoned single phase current.

I may here take the opportunity of replying to a question put by Mr. Gerard : Why has the Midi Company returned to the use of continuous current ?

I should have replied to Mr. Gerard, if I had been able to speak at the time; but, as this was not possible, I will do so now.

In France the question of the standardization of the type of current has arisen more as a political than as a technical question. Actually, the standardization of the different types of electric traction current was required by the Government because it thought it necessary that the electric locomotives of one railway system should be able to run over the other railway systems. Under these conditions the type of current had to be made uniform. The majority of the railway systems having decided to adopt continuous current at 1 500 volts the Midi Company had no choice in the matter.

With regard to what concerns me personally, that is the difficulties that we have experienced in disturbances caused by the alternating current on the telegraph lines, this has been one of the reasons that has led me to support the continuous current as the solution of the difficulty.

The President. — Has the matter not been taken up with the telegraph administration so that the latter may collaborate in overcoming the difficulties that the traction current engenders?

Mr. Bachellery. (In French.) — The French Railways Companies always endeavour to obtain the collaboration of the telegraph Administration in solving any difficulties that may arise, but they have not in reality any means of influencing this Administration.

Mr. Gerard, *special reporter.* (In French.) — It appears to follow from the remarks of Mr. Bachellery that it is not a purely technical reason that has been the cause of the rejection of alternating current on the French Midi Railway System but that it has arisen from reasons that are rather outside any technical and economic considerations, at least in so far as concerns the engineers of the railways and the electrical engineers. Another power alongside or above them has deprived them of complete liberty of action.

The United States is in the happy position of enjoying much greater liberty. In that country standardization is not so much sought after as on the Continent of Europe.

This does not prevent me from wishing to learn from Mr. Bachellery, whether, given the example of Switzerland, which has deliberately removed its telegraph lines from alongside its railway system, it would not have been possible on a particular railways system, such as that of the Pyrenees, to adopt the Swiss solution for the telegraph and telephone lines; that is to say to avoid the difficulties of engaging in an expensive struggle by arranging special installations to counteract the effects of induction, and, instead, to run the wires over the mountains and thus effect telegraphic communication across country.

Mr. Lanino. (In French.) — In Italy in 1898 the disturbances due to induction were already known. It was then I think that the question began to assert its full importance. After some trials it became necessary to move the telegraph and telephone lines, and, after twenty-five years of experiment we are still in the position that, in our opinion, the only practical method of preventing the disturbances consists in removing the telegraphic and telephonic lines to a distance. This system, of course, is very costly, particularly when it involves much complication. The other day Sir Philip Dawson mentioned the cases in which the telephone lines had had to be moved for a considerable length as in England. In this case the question of expense becomes so serious that it may influence such a solution if, actually, any effective method is to be found to prevent the disturbances.

I would also observe that in Italy the situation from one point of view is the same as it is in France. I can speak freely because I do not belong to a State Administration nor do I work for a private Company. There is always one Administration, that of the telegraphs for example, which requires special considerations. It finds a favourable opportunity for improving its line at the expense of electric traction. (*Laughter.*) And it is well-known that each Administration only looks to its own budget and not to the general budget of the State. (*Renewed laughter.*) At the present time it goes so far as to ask that the telegraph and telephone lines shall be moved to a distance of several kilometres from the railway lines. It is a sort of standardization of electric installations and looks as if consideration has to be taken of the fact that in all transmissions for electric traction it is necessary to displace any lines which run alongside the rails. This is rather a question of organization which results from the system.

I should further like to observe that in Italy trials have been made of putting the telegraph lines in cables. But even then, when these cables are laid alongside the railways, phenomena of electrostatic discharges occur which produce difficulties.

There are also other phenomena. It must not be thought that the use of the continuous current system is a pure and simple solution of the whole question of telephonic disturbance.

Mr. Bachellery. (In French.) — I fear that I have not expressed myself well. I said that in France the problem of standardization had arisen rather as a question of general politics than as a technical question, but I did not say that the selection of the system had been dictated by reasons outside of technical considerations. The choice of the type of current adopted for the whole of the French Railway System has been made as the result of an extremely searching technical enquiry in the course of which the various types of current were studied in Europe and in the United States, and it is these technical and economic considerations that have resulted in making the railway systems agree on the type of current that has been proposed to the Government.

So far as I, personally, am concerned, I have said that the difficulties relating to induction in the telegraph lines which we have had to fight in the case of the single phase current have been one of the most serious arguments that influenced me in favour of the continuous current.

Mr. Gerard has put this question to me : Would it not have been possible to adopt the same solution as in Switzerland, that is to say to take the telegraph lines away from the railway track? It is a solution that we have considered. When we began to run with single phase current we followed, with the greatest interest, the experiments which were being carried on simultaneously in Switzerland on the Loetschberg line and we considered the displacement of the telegraph line. That we did not carry this out, was because we thought that it would result in extremely heavy expense, an expense that was actually prohibitive, far in excess of the expense that would arise from the installation of protective apparatus on our line. We therefore preferred the latter solution.

Mr. Semenza. (In French.) — I have the impression that in the discussion of a problem of so great importance confusion always occurs between the economic and the technical sides. If these two aspects could be separated the question would become much clearer.

From the technical point of view we have only to ask ourselves whether it is possible to eliminate the phenomena of induction. I think that the reply would be, in most cases, that it is possible to reduce them to a reasonable amount. If there are cases in which this is not yet possible we should hope that in a short time, with the progress of technical knowledge, it would be possible.

From the economic point of view the question should be put thus. All electrification involves the necessity for protecting the communication lines against induction effects and requires more or less heavy expenditure. This expenditure must be taken into account just as is that which is charged against the poles, the copper, etc. From the economic point of view the induction phenomena may therefore exercise an influence on the choice of the system.

Mr. Parodi. (In French.) — I do not see amongst our American friends any representatives of the lines that have made installations using high-tension continuous current. I think therefore it would be as well to note that in the course of our mission to the United States two years ago in connexion with the question of the selection of a traction system, we made tests in which the American telegraph and telephone companies collaborated. These tests had for their object the finding out, whether or not, in continuous current installations, induction effects were produced comparable to those which were found on the alternating current lines. The American engineers assured us that the effects existed with continuous current installations, but not to the same extent as on installations using alternating currents.

The tests which had been made on the Chicago-Milwaukee line in the presence of representatives of the French Minister of Posts and Telegraphs have shown that in the case of short circuiting, no serious disturbing effect was produced on the ordinary telegraphic apparatus or on the telegraphic printing apparatus. In these experiments, arrangements were invariably made to have a length of 124 miles of lines arranged parallel with each other.

It is obvious that, with continuous current, heavy expenditure is not needed, whereas, with single phase current the expense is greater the greater the length of the line.

From the point of view of the action of induction on the telephones lines there is no room for any doubt.

Mr. Huber. (In French.) — It has just been said that one of the reasons that militate in favour of continuous current is that it costs much less. In Switzerland we arrived at quite a different conclusion. In calculating the cost of the single phase system we included all the expenses which we should have to incur to guard against disturbances produced by the traction current in lines carrying weak currents, and assumed in favour of continuous current that all these expenses would be reduced to zero, we have actually worked out that the expense of first cost for the single phase system would be 6.3 % less than it would be for continuous current. This is, it appears to me, an important consideration: but it should not cause another consideration to be lost to sight, and that is that according to our calculations the cost of working the single phase system is much less than the cost of working the continuous system.

Mr. Duer. — I believe that, insofar as the Pennsylvania Railroad is concerned, it is possible to avoid inductive effects on the lines of communication without supplementary expense.

— No other person having expressed the desire to speak, the discussion was closed.

DISCUSSION AT THE GENERAL MEETING

Meeting held on 26 April 1922 (morning).

Mr. R. de CORNÉ, HONORARY VICE-PRESIDENT, IN THE CHAIR.
General secretaries : Mr. J. VERDEYEN ; Mr. E. FRANZA ; Sir Henry FOWLER.
Assistant general secretary : Mr. N. GIOVENE.

Sir Henry Fowler, *general secretary*, read the

Report of the 2nd section.

« (See *Daily Journal of the session*, No. 6, p. 10, No. 7, p. 9 and No. 8, p. 7.)

« Mr. Ernest Gerard (*special reporter*) read the final part of his report. He pointed out that the questionnaire was not restrictive, but intended to state the issue in plain terms.

« The President suggested and the section agreed to take Mr. Gerard's summary in paragraphs.

« *Paragraphs 1, 2 and 3 : Type of current.*

« Mr. Semenza (*Italian Government*) regretted that the suggested summary did not lay stress on the necessity of studying the various economical and technical points of the systems in order to assist in the selection of the most suitable one.

« Mr. Gerard recalled the discussion at the Congress at Berne in 1910, which showed the interest which should attend on discussion of the proposed text.

« Mr. Huber (*reporter*) and Sir Philip Dawson (*London, Brighton & South Coast Railway*) stated they could agree with the proposed text : they were of opinion that the selection of the system depended on so large a number of factors that it was practically impossible to lay down any hard and fast rules.

« Mr. Sabouret (*reporter*) was of quite a different opinion, and mentioned that in France they had been able to adopt a universal system and pointed out the resulting advantages.

« Mr. Sayers (*Great Central & Midland Railway*) called attention to the inductive effects of the traction lines on telegraph and telephone lines. On British Railways these effects have probably been the determining factor in the selection of the direct current system by the Government Electrification Advisory Committee; other advantages and disadvantages in systems being about equal.

« Mr. **Huber** said that it was a good thing if the telegraph and telephone authorities could move their wires from the neighbourhood of the traction lines; in some cases however this could not be done. In Switzerland therefore the possibility of moving the wires had not been the determining factor in the selection of the system to be employed.

« Mr. **Sabouret** proposed that a modification to the end of paragraph 1 be discussed.

« **The President** would have liked to have had a text more positive than that proposed by Mr. Gerard expressing more clearly the ideas of the delegates; he would prefer a wording stating categorically that none of the systems can be considered as a standard one, applicable to all cases.

« Mr. **Sabouret** spoke of the desirability on a large railway, which was run partly by hydro-electric installations and partly by steam driven plants, of connecting the generating stations together. He mentioned the Paris-Orleans as an example of this.

« Sir Philip **Dawson** pointed out that in his opinion paragraph 3 only examplifies paragraph 1.

« Mr. **Lanino** (*Italian Government*) supported the wording proposed by Mr. Gerard, and defended the different methods of electrification adopted by the Italian State. In his opinion the most important thing was the standardisation of coupling and draw gear so as to prevent unnecessary trouble in shunting, etc., at frontier stations.

« *Paragraph 4 : Records and statistics.*

« Mr. **Duer** (*Pennsylvania Railroad*) considered that the standardisation of the records for international account keeping was difficult, because it is frequently impossible to separate entirely the electrified from the non-electrified parts of the railway.

« Sir Henry **Fowler** (*Midland Railway*) stated that in his opinion it was almost impossible to give figures for the « virtual ton-kilometre » which would have any practical value.

« Mr. **Parodi** (*Paris-Orleans*) agreed with Sir Henry Fowler and pointed out that the tractive force required per ton varied with the varying total weight of the vehicles.

« Mr. **Huber** pointed out that is was a matter of great interest to arrive at an understanding with regard to the method of calculating the virtual ton-kilometre and determining the amount of energy used for traction.

« Mr. **Semenza** was in agreement with Mr. Huber, but thought that the definition of virtual ton-kilometre or virtual length adopted with steam traction need not of necessity be agreed to for electric traction.

« Mr. **Lanino** spoke on the advantages which would accrue from an agreement on the subject of standardising the definition of the fundamental units on railways. This work ought to be delegated by the present Congress to an International committee on which all sections ought to be represented.

« Sir Henry **Fowler** moved that in the place of paragraph 4 a fresh one he had drawn up should be adopted, and the proposal was carried. (The new wording is given in the summary and is there numbered three.)

« *Paragraph 5 : Overhead conductors.*

« Mr. Pattison (*Illinois Central Railroad*) said that from his experience it was desirable to duplicate the contact wire on main lines with heavy traffic if the voltage was 3 000 or less.

« Sir Philip Dawson gave some very interesting information about the wear of the contact wires on his company's lines. He said it was negligible at points where there was no consumption of current and where there were no steam locomotives running. Abnormal wear had been avoided by the prevention of hard points, and generally speaking he could say the wear is more than proportional to the current collected.

« Mr. Van Loenen Martinet (*reporter*) wished to know the recent results given by the working conductor of the Chicago, Milwaukee & St. Paul Railroad.

« Mr. Semenza said that he had visited that installation in the summer of 1921 and that the double contact line had behaved extremely well, both as regards absence of sparking and wear and tear.

« Replying to a question of Sir Philip Dawson, Mr. Semenza stated that owing to the industrial crisis the number of trains had been reduced to about twelve per day.

« Mr. Öfverholm (*reporter*) stated that with a catenary system in which the suspension points of the contact wire were spaced 19 yards (17 m.), the collecting of the small current required by a 11 000 volt system caused no trouble.

« Mr. Parodi said that there was practically no wear on the wires of the Nord-Sud (Paris) Railway, where the voltage was 600 and the current usually collected 1 000 amperes.

« Mr. Donati (*reporter*) said that after the long experience which had been obtained on the Valtellina line, entire satisfaction had been given on that line by the installation of transverse suspension. He stated that on a three-phase line in the vicinity of Turin the delays due to the contact wire were but 80 minutes per month out of 2 080 minutes total delay.

« Mr. Lanino spoke of how difficult it was to separate the question of the type of suspension from that of the choice of type of current. In Italy, in the majority of cases, the cost of the contact line is a secondary consideration. In other countries where heavy gradients and sharp curves are rare and the distances great, other considerations prevailed, and these considerations ought not only to influence the type of contact line employed, but equally the choice of system.

« Mr. Sayers stated that his company had experimented for fifteen years largely with the object of obtaining an overhead contact wire free from hard points, and the result of this experience was entirely in favour of catenary suspension; in fact to avoid vertical inertia necessarily associated with pull-offs he had devised a system which dispensed entirely with separate pull-offs, in which every dropper was a pull-off, and this had run with great success.

« He suggested that the question as to whether transverse or catenary suspension was more desirable depended on the speed of the traffic and the quantity of current to be collected.

« The President supported Mr. Sayers' view, and was of opinion that no other system than the catenary could be satisfactory for the railway with a heavy traffic and fast trains.

« Mr. Donati pointed out that on the three-phase Italian lines simple transverse ,suspension gave excellent results, even for speeds up to 100 km. (62 miles) per hour.

« *Paragraph 6 : Utilisation of same current distributing scheme for rail traction and industrial uses.*

« Mr. Gerard pointed out that this was of great interest in countries where a single system of supply must be applied for all purposes.

« Mr. Lanino mentioned instances of the use, in Italy, of high frequencies for traction purposes.

« Mr. Huber insisted that difficulties must arise in endeavouring to connect, either directly or by means of transformers, industrial and traction supplies from the same source of power owing to the troubles caused by the sudden heavy demands for current by the traction lines.

« Mr. Parodi stated that when on a visit to the installations of the « Société des forces motrices bernoises » which supplied current to the three-phase line from Berthoud to Thun, he had not ascertained that any such difficulty existed.

« Mr. Donati thought that there was some hope of overcoming these difficulties by means of voltage regulators of modern design and by regulators governing the turbines.

« Mr. Lanino concluded the discussion of this paragraph; he showed that the problem of connecting the traction line with the industrial one must receive a solution in countries little developed industrially, like Southern Italy, and that, on the other hand, the same problem was of secondary interest in the countries having great industrial development.

« *Paragraph 8 : Multi-traction.*

« Mr. Sabouret (*reporter*) wished to know why single-phase current has been abandoned on the Norfolk & Western Railway in favour of the split-phase system.

« The President explained the chief reasons for the choice that was made. In the first place the length of the trains caused very great difficulties in starting the locomotives simultaneously, with the result that a heavy current passed through the motors whilst standing. In addition to this, the importance of the gradients and the necessity of recuperation had to be considered. The general conditions of the line, especially of one tunnel in the section, made it impossible to put up two overhead conductors for direct collection to the three-phase motors; hence the necessity for collecting from a single-phase contact wire and converting to three-phase through the phase splitter.

« Mr. Huber stated definitely that in Switzerland the single-phase system on some lines, not less difficult than those of the Norfolk & Western, caused no trouble. The locomotives are employed in multi-traction as simply as steam locomotives.

« At this point, and before the adjournment, Mr. Van Loenen Martinet wished, in the name of the foreign delegates, to offer to their Italian colleagues their congratulations on the occasion of the « Noël de Rome ».

« The reporters met together to edit the summmary.

« The President said he proposed to

devote some time to an exchange of information on : *a*) the direct supply of high tension direct current to the motors; *b*) inductive effects.

« Mr. Semenza said he would be glad if the section would also deal with the important question of the transmission of the movement of the rotors of the motors to the axles, and also to the question of the recuperation of energy.

« The President said he thought Mr. Semenza's suggestions were rather too detailed for the consideration of the Congress, but would see if the section could before completing find time for their discussion.

« Mr. Sabouret asked that the Italian and Swiss delegates would give information as to the tractive effort permitted on their lines.

« Mr. Huber said that in Switzerland the limit had been raised from 10 to 15 tons, and on the Gothard line trains of 800 tons were handled with one locomotive at the head and one at the rear of the train.

« Mr. Donati stated that in Italy also they reached a limit of 15 tons for the tractive effort, the adhesive weight being limited to 60 tons.

« a) *Direct supply of high tension direct current to the motors.*

« The President called attention to the advantage, as far as shunting in the terminal stations is concerned, of the American practice in which the use of trailers was entirely abandoned.

« Mr. Japiot (*Paris-Lyons-Mediterranean*) said it was quite possible to effect shunting by the sectioning of trains in the terminals, although the trains were formed of a certain number of motor cars and trailers.

« Mr. Duer explained that on the Pennsylvania Railroad there were only motor cars used, that the terminal stations had not been provided with a sufficient number of side tracks for the switching of trains and groups of vehicles and that the cost of fitting all the cars was not so high as might be thought. The solution adopted by his Company avoided all the difficulties or failures which result from the overloads of a motor car called upon to haul too great a number of trailers; overloads which were bound to be permitted or ordered by the traffic department, at more or less frequent intervals, in emergencies.

« Mr. Parodi stated that on the French State Railway they had at first fitted all the cars with motors. After a certain time it was recognised that the use of trailers caused no difficulty.

« Mr. Donati stated that in Italy on the Milan-Varese line with a third rail they had come to the same conclusion.

« b) *Inductive effects.*

« Mr. Huber stated that in Switzerland there was no difficulty owing to the complete understanding between the railway and the telegraph and telephone administrations, all problems had been solved to the entire satisfaction of the administration concerned. The administration of the telegraphs and telephones had been satisfied with renewing some lines and putting others in underground cables.

« The President mentioned a case where at the beginning of the working of a tramway line the authorities had obliged the tramway company to abandon the return by rail and instal overhead wires for supply and return, in order to prevent the inductive effects on the telephonic circuits. He added there could be no question of discarding a traction system because there was not yet in existence devices sufficiently perfect to do away with inductive effects.

« Mr. BACHELLERY (*Midi Railway of France*) said that his company had run for ten years a main line 31 miles (50 km.) long with single-phase current fed in at one end only. They had met with very great difficulty arising from the electro-dynamic and electrostatic induction on the telegraph and telephone wires running alongside the track. Following complaints from the telegraph administration, they had carried out very extensive experiments and trials with a view to finding a remedy. They had arrived at a satisfactory solution of the problem by providing a return « feeder » with sucking transformers placed every 2 1/2 miles (4 km.), and by providing a screening wire. In all cases this arrangement cost a good deal of money and it has not been shown that a less costly solution is not possible in bringing the points where the line is fed closer together such as is done in the United States.

« This question, however, had lost most of its interest in France, where the decision of the Government to insist on a single system on all the main lines employing electric traction had resulted in the adoption of continuous current at 1 500 volts.

« Mr. Bachellery added that the difficulties which had arisen on his railway owing to the inductive effect of the single-phase traction current on lines with weak current had been one of the factors which led to the adoption of continuous current.

« Mr. LANINO remarked that with the very first application of the three-phase traction, the Italian State had removed the « telecommunication » lines. In his opinion that was the safest means. Mr. Lanino considered that the use of direct current did not do away with all the disturbing effects.

« Mr. FIORI (*Italian State*) stated that when the members visited the line Genoa-Bardonecchia they would have an opportunity of studying a new system of telegraphy by high frequency current devised by Italian engineers.

« Mr. SEMENZA thought the question should be put as follows :

« *a*) Technically, it is always possible, or in a very near future it will always be possible, to neutralise the inductive effects;

« *b*) Economically, the doing away with the disturbing effects gives rise to expense which should be taken into account.

« Mr. PARODI, who was supported by Mr. DUER, stated it resulted from experiments made in America, namely on the Chicago, Milwaukee & St. Paul, that no disturbing effect is to be feared with the use of direct current, even in the case of a short circuit. »

The President. — In the first place I will put paragraphs 1 and 2, and the first part of paragraph 3, to the vote :

« 1° The Congress recognises that at present a single system could not be recommended for all cases any more than in the past, nor is it possible to choose between several systems, all of which have prooved their value under the most severe conditions of operation; the Congress recognises, moreover, that these systems are all susceptible of considerable further improvements;

« 2° The Congress agrees on the uselessness of standardisation of the type or pressure of current in the contact wire on account of the ease with which locomotives may be changed at the frontiers of the different countries;

« 3° It is desirable that the methods of keeping and supplying technical and economical information on electric traction should be defined and standardised. »

— Adopted.

The President. — The second part of paragraph 3 points to the examination of the question by a special Commission of the International Association with a view of its inclusion in the agenda of the next session of the Congress. This part should evidently be approved independently of what has been previously found.

No one having expressed the desire to speak I will put the second half of the text to the vote :

« And with this in view, the section suggests that this point be referred to a special committee of the Association. This committee should draw up very fully the details governing each point so that in future as full a comparison as possible may be made by means of figures absolutely comparable. »

— Adopted.

The President. — This is the

Final summary.

« 1° The Congress recognises that at « present a single system could not be « recommended for all cases any more « than in the past, nor is it possible to « choose between several systems, all of « which have proved their value under « the most severe conditions of operation; « the Congress recognises, moreover, that « these systems are all susceptible of « considerable further improvements;

« 2° The Congress agrees on the useless- « ness of standardisation of the type or « pressure of current in the contact wire « on account of the case with which « locomotives may be changed at the « frontiers of the different countries;

« 3° It is desirable that the methods of « keeping and supplying technical and « economical information on electric « traction should be defined and stand- « ardised, and with this in view, the « section suggests that this point be re- « ferred to a special committee of the « Association. This committee should « draw up very fully the details govern- « ing each point so that in future as full « a comparison as possible may be made « by means of figures absolutely com- « parable. »

— The general meeting ratified this summary.

[621 .133.1]

MOTION

RELATING TO THE DRAFTING OF THE LIST OF QUESTIONS OF THE NEXT SESSION.

Utility of studying the question of the use of liquid fuel in locomotives.

Preliminary documents.

Note by Sir Henry Fowler. (See English edition of the *Bulletin* of August 1921, p. 923, or separate issue [with red cover] No. 22.)

Special note summing up this motion by Sir Henry Fowler. (See English edition of the *Bulletin* of April 1922, p. 726.)

SECTIONAL DISCUSSION

Meeting held on 27 April 1922 (**morning**).

Mr. VAN LOENEN MARTINET, VICE-PRESIDENT, IN THE CHAIR.

The President. (In French.) — Sir Henry Fowler has the floor.

Sir Henri Fowler read the special summary which he had prepared and which has been published in the *Bulletin* of April 1922.

The President. (In French.) — The conclusions of Sir Henry Fowler include two paragraphs of which the first is :

> There are no mechanical difficulties in the adoption and use of liquid fuel for locomotives. The question of cost both of the fuel and maintenance makes its use, however, prohibitive, except in certain localities, and these are so restricted that the subject is not recommended for discussion by a further session of the Congress.

I call on Mr. Van Schouwenburg.

Mr. Van Schouwenburg, Dutch Indies Railway Company. (In French.) — The company which I represent has had occasion to make trials of liquid fuel in the Island of Java, which is near petroleum fields.

I agree with the views expressed by Sir Henry Fowler in the first part of his report. The actual difficulties of the question arise from the price of the fuel. When it is proposed to use petroleum to any great extent, those who hold stocks of this fuel oil raise the price to such a figure as to prevent the advantages, which it was hoped to obtain, materialising, and one has to fall back upon the fuel previously used.

Nevertheless, I think that Sir Henry Fowler is going a little too far in saying that because of the question of price the subject should be eliminated from the programme of the next session of the Congress. It seems to me that it would be better to leave the question open rather than formally decide that we should not deal with it.

Sir Henry Fowler. — I admit that there may be a change in the future in the conditions of world's supply of crude petroleum, and therefore agree with Mr. Van Schouwenburg that my first conclusion should be made less positive.

The President. (In French.) — It must therefore be indicated that, owing to the relative prices of coal and liquid fuel, it is of no interest to continue the examination of this question for the moment. In consequence, the conclusion will be modified as follows :

« There are no mechanical difficulties in the adoption and use of liquid fuel for locomotives. The question of cost both of the fuel and maintenance makes its use, however, prohibitive at present, except in certain localities, and these are so restricted that the subject is not recommended for discussion immediately. If prices should vary, it might, however, be desirable that it should receive consideration later. » (*Assent.*)

— This conclusion is adopted.

The President. (In French.) — The second paragraph of the conclusions is :

The question of the use of liquid fuel in conjunction with internal combustion engines on locomotives is, however, one of more general interest and might be considered later.

Sir Henry Fowler. — The 5th section has dealt with the same subject in the discussion on question XIX.

The President. (In French.) — Under these conditions, is the question important enough to justify the maintenance of the second paragraph of the conclusions in what concerns normal gauge railways?

Mr. Bochet has the floor.

Mr. Bochet, Ministry of Public Works, France. (In French.) — It appears to me that it would be of interest to put this question on the programme of the Congress. Internal combustion engines have made, for a considerable number of years, very marked progress, and it is very possible that in the next five or ten years they may improve still more, and the question is one of immediate interest. It seems to me that it is an opportune time to put forward this question for the programme of the next session.

The President. (In French.) — I propose to send Sir Henry Fowler's motion to the central committee, so that the latter may state what course should be followed. (*Assent.*)

— This shall be done.

Sir Henry Fowler. — I believe I am voicing the opinion of all the members of the 2nd section when I express to our President, as well as to our Vice-President, Mr. Van Loenen Martinet, and to our secretaries, the sincere thanks of the section for the business-like manner and for the courtesy with which they have conducted the work of the section. (*Applause.*)

The President. (In French.) — For my part, I thank the members of the second section who have taken part in our work and I congratulate the secretaries, whose pains have ensured the success of our deliberations. (*Applause.*)

DISCUSSION AT THE GENERAL MEETING

Meeting held on 28 April 1922 (morning).

Mr. R. DE CORNÉ, HONORARY VICE-PRESIDENT, IN THE CHAIR.
GENERAL SECRETARIES : Mr. J. VERDEYEN; Mr. E. FRANZA; Sir HENRY FOWLER.
ASSISTANT GENERAL SECRETARY : Mr. N. GIOVENE.

Sir Henry Fowler, *general secretary*, read the

Report of the 2nd section.

« (See *Daily Journal of the session*, No. 9, p. 9.)

« THE PRESIDENT asked Sir Henry FOWLER to give a summary of his report, which he did.

« Mr. VAN SCHOUWENBURG (*Dutch East Indian Railways*) thought that the first paragraph of the proposals was too definite because the price of liquid fuel ought to be cheaper in the future.

« Sir Henry FOWLER agreed to this suggestion, and proposed the text given below, which was approved.

« With regard to the second paragraph of the summary Sir Henry Fowler called attention to the fact that the 5th section dealing with question XIX had called attention to the same point.

« THE PRESIDENT asked if it was really necessary under these circumstances to retain the second paragraph with regard to standard railways.

« Mr. BOCHET (*French Government*) asked that it should be allowed to remain, bearing in mind the improvements which are possible with internal combustion engines.

« — The section approved of the second paragraph. »

The President. — This is the

Motion.

« 1° There are no mechanical difficul-
« ties in the adoption and use of liquid
« fuel for locomotives. The question of
« cost both of the fuel and maintenance
« makes its use, however, prohibitive at
« present except in certain localities, and
« these are so restricted that the subject
« is not recommended for discussion im-
« mediately. If prices should vary, it
« might, however, be desirable that it
« should receive consideration later;

« 2° The question of the use of liquid
« fuel in conjunction with internal com-
« bustion engines on locomotives is, how-
« ever, one of more general interest and
« might be considered later. »

— The general meeting agreed to this motion and remitted it to the Permanent Commission for consideration.